

Lieutenant General Hallin Discusses The New Logistics Paradigm—Agile Combat Support

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AIR FORCE JOURNAL *of* LOGISTICS

Volume XXI,
Numbers 3 and 4

This is a consolidated issue which consists
of AFRP 25-1, Volume XXI, Numbers 3 and 4.

AIR FORCE JOURNAL *of* LOGISTICS

Volume XXI, Numbers 3 and 4

AFRP 25-1

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Approval Statement	The Secretary of the Air Force has determined that the publication of this periodical is necessary in the transaction of the public business as required by law of the Department. Use of funds for printing this publication has been approved by the Secretary of the Air Force, 17 July 1986, in accordance with AFI 37-160V4.
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Agile Combat Support—The New Paradigm

Lieutenant General William P. Hallin, USAF

Introduction

Our nation's military is no longer postured to engage only in major theater war; rather, it has broadened its focus to include small-to-medium-scale deployments supporting differing geopolitical objectives. *Joint Vision 2010 (JV2010)* outlines the Department of Defense (DoD) vision that will enable joint forces of the future to be more responsive to our national security environment. (1) Specifically it calls for logistics systems to be responsive, flexible, and precise—an operational concept called "Focused Logistics." The Air Force Vision of Global Engagement defines core competencies that enable the Air Force to bring effective air and space power to the joint commanders in chief (CINCs). (2) Agile Combat Support is the core competency that establishes the role of the logistics and support community in Global Engagement consistent with *JV2010*.

Military operations and their associated combat support infrastructure must evolve to support the increased emphasis on force protection and the deployment of an Air Expeditionary Force. Decreases in funding and the drawdown of the US military continue to force new approaches to employment of military forces, support operations, and refinement of the military logistics system. These fiscal constraints require us to reduce infrastructure, maintain smaller numbers of both inventory and personnel, and find ways to reduce costs without degrading mission capability.

Reduced budgets impact weapons modernization programs. As dollars decrease, important decisions must be made in the acquisition process that consider the life-cycle cost of sustainment for our weapon systems. The process must develop the most lethal systems, while emphasizing reliability and supportability. Therefore, logistics considerations play a more important role than ever in the design, production, and fielding of new systems. Combat support capabilities for supporting future contingency operations involving our forces require systems to be "smarter" and require less maintenance and infrastructure. This includes designing self-diagnosing systems and ensuring that systems and components are reliable enough to decrease the need for spares purchases and support manpower.

Technology not only affects the development and sustainment of weapons systems, but also offers the opportunity to modernize the information infrastructure. This will facilitate joint operations, provide timely access to data, and enable electronic interface to the commercial sector. The tremendous explosion in information technology will improve our ability to maintain asset visibility and prioritize and analyze information for effective command and control in a warfighting environment. Improved logistics data reliability and total asset visibility must be accomplished in the development and enhancement of information systems. The modernization and integration of

information systems will allow for real-time visibility of data, enabling decision makers to act upon current, accurate information.

Agile Combat Support

A cross-functional doctrine working group of major command (MAJCOM) and Air Staff representatives, sponsored by the newly formed Air and Space Doctrine Center, recently developed the following definition for the new Air Force core competency: "Agile Combat Support is the cornerstone of Global Engagement and the foundation for the other Air Force core competencies. Agile Combat Support creates, sustains, and protects all Air and Space capabilities to accomplish mission objectives across the spectrum of military operations. Agile Combat Support provides the capabilities that distinguish Air and Space power—speed, flexibility, and global perspective." As you can see, this definition gives Agile Combat Support a scope that more closely reflects the joint definition of logistics. The traditional scope of Air Force logistics, consisting of maintenance, transportation, supply, and logistics plans functions, has now been expanded under Agile Combat Support to include services, civil engineering, security forces, communications, medical, judge advocate, chaplain, and personnel. Agile Combat Support has attained equal billing with combat operations because of the enabling role combat support plays in providing the responsiveness, flexibility, and precision required for success of all the core competencies.

**Agile Combat Support is the
cornerstone of Global Engagement and
the foundation for the other Air Force
core competencies.**

Logistics Principles of Agile Combat Support

Agile Combat Support places emphasis on several distinct principles that describe how our logistics community contributes to this core competency. The principles are founded on a concept called "Lean Logistics," which the Air Force began to implement in 1994. The capabilities inherent in the Lean Logistics concept create a system whereby the needs of a deployed force will be met by responsiveness of the logistics pipeline in lieu of large stocks of spares. Lean Logistics requires rapid transportation from origin through battlefield distribution, utilizing the

capabilities of both commercial contract carriers and military lift. Lean Logistics also requires substantial reengineering of the depot repair processes to make them more responsive and reliable, as well as to reduce the cost of depot operations.

Responsiveness Versus Massive Inventories

Under the Agile Combat Support concept, the focus of the support system shifts from maintaining massive inventories to establishing response capability. The key to successfully developing a responsive system is to emphasize efficient business-based management, time-sensitive responsive transportation, reduced forward-deployed inventories, accurate support command and control, and focused depot-level repair. A responsive pipeline should support the warfighter by providing required resupply expeditiously, using efficient process management to reduce cycle times. Resupply requests must be filled in priority order, with information systems capable of supporting the prioritization and supplying visibility to the recipient while the materiel is in transit. If all of these characteristics are met, the need for massive inventories in the pipeline and at deployed locations will be eliminated.

We will employ high-velocity processes in lieu of large inventory levels to manage mission and logistics uncertainty. This will increase operational capability, reduce the mobility footprint, and streamline inventory while cutting cost. To make this concept a reality, we must test and exercise it, then work with the CINCs to incorporate it into their operation plans (OPLANs).

Under the Agile Combat Support concept, the focus of the support system shifts from maintaining massive inventories to establishing response capability.

Effective Beddown and Sustainment

In order to reduce forward-deployed inventories, we must embark on a rigorous base support planning effort. This will allow assessment of what a deploying force must bring with it, versus what it can obtain locally. This includes support provided through leasing or host nation support agreements. There are opportunities to acquire many resources through these means instead of buying and stockpiling war reserve materiel (WRM). However, host nation constraints must be accounted for during support planning. Laws and customs may limit access to local resources. Advance planning and training can minimize the impact. Although one goal of Agile Combat Support is to reduce forward-deployed inventories, even under the Air Expeditionary Force concept, these stocks cannot be eliminated. Deploying forces must still rely on some prepositioned assets to spin up deployed forces and begin immediate sustainment, particularly in the areas of fuel and munitions.

To effectively begin operations in a forward location, the deployed forces must rely on critical organic resources, such as RED HORSE, Prime RIBS, and Prime BEEF to acquire and

construct minimum base infrastructure, while commercial contracts will, in the future, provide an important part of our sustainment strategy. Local equipment and supplies should be considered to replace Harvest Falcon and other deployable assets if this will improve the responsiveness and maintain the living standards set for the deployed forces.

Time-Definite Resupply

The concept of time-definite resupply embodies time-definite delivery and immediate resupply and/or sustainment of a deployed force. By providing users with reliable, predictable delivery of mission critical parts, time-definite delivery gives users the confidence to reduce investment in both cycle and buffer stock inventories. It will form the basis for all resupply in-theater, thus reducing total lift requirements. When commanders require an item, the system will reach back to the Continental United States (CONUS) and deliver it where and when it is needed. This will be accomplished through the seamless transition from the strategic airlift and sealift to the intra-theater battlefield distribution system. The intra-theater battlefield distribution system will rapidly deliver the item to the point of usage. This reach back approach will make it possible to deploy fewer functions and personnel forward for the deployment and sustainment processes. Time-definite resupply will reduce airlift requirements by reducing the size of our deployed forces.

CONUS Reach Back

Reach back encompasses the complex network that transfers information regarding weapons system status and requirements. It is the concept whereby the CINC's staff and deployed units seek support from rear or CONUS-based organizations. Deployed units transmit requests for support and status reports back to CONUS. The status reports provide the mechanism for prioritization of requests and order of replenishment. This process should be supported by information systems, which ensure that the top priority requirements are automatically identified and delivered by the fastest transportation mode. The success of reach back depends on seamless data flow from the forward location through the entire support pipeline.

Information Technology

Agile Combat Support must be enhanced through exploitation of advances in technology, communications, and information systems integration. Our vision in information technology includes a roadmap for enhanced command and control through an integrated Global Combat Support System (GCSS) which will be linked to the Global Command and Control System (GCCS).

A key example of leveraging information technology is Total Asset Visibility (TAV). This concept captures information on assets being repaired, moved, or stored, as well as passenger movement status. Information available from vendors to points of use (factory to flight line) will support a quick response capability and reduce reliance on large stocks and maintenance infrastructure. TAV will also enhance planning and support integration by allowing support personnel to know where an asset is, requisition it, and track it from source to destination. The result will be a system far more capable, flexible, and economical than previous support operations—all managed at reduced total cost.

A second example of leveraging technology is the use of automated identification technologies that include bar coding and radio frequency identification tags. These technologies will

streamline asset handling at critical nodes throughout the pipeline and support the TAV concept. In the final analysis, logistics will be an important part of what is called the "Common Operating Picture," which provides the Theater CINC the information needed to prosecute the war.

Effective Installations

Air Force installations are the springboard from which we deploy and employ air power. For our installations to effectively act as springboards to employ air power, we must ensure facilities are available to ready, position, employ, sustain, and recover our air and space forces. This includes base infrastructure and facilities, housing and food service, as well as quality of life features such as recreation, family support, and fitness facilities. A primary objective of installation support is providing a "sense of community" so that airmen and their families feel secure and supported when they are at home base or in a deployed location. The private sector can perform many base level functions at reduced cost, as evidenced by the results of outsourcing studies. The Air Force is committed to achieving substantial cost savings through prudent outsourcing and privatization initiatives at its installations.

Installation support also encompasses force protection and threat suppression. This includes providing appropriate security forces and nuclear, biological, and chemical attack detection and warning, as well as planning for asset and personnel protection from enemy attack or terrorist actions. Reducing vulnerability of support structures and employing safeguards to provide early warning and detection of threats ensures installations are capable of supporting the mission at all times.

An additional element of effective installations is environmental quality. Environmental quality must be maintained during contingency operations and at our permanent installations so we will be in compliance with the law, be good stewards of national or host nation natural resources, and ensure

the long term availability of our installations and ranges for military use. The Air Force will continue to be a leader in environmental quality.

Agile Combat Support is a key enabler that spans the entire logistics pipeline from "factory to flight line."

Conclusion

Agile Combat Support is a key enabler that spans the entire logistics pipeline from "factory to flight line." It builds on the fundamental logistics principles of responsiveness, simplicity, flexibility, economy, attainability, sustainability, and survivability. Agile Combat Support, as one of the six core competencies, will help launch the Air Force into the 21st Century and achieve its vision of Global Engagement. Every logistician in the Air Force should be an "Agile Combat Support Champion" and make this vision a reality.

References

1. Chairman of the Joint Chiefs of Staff. *Joint Vision 2010*, Washington DC: U.S. Government Printing Office, Sep 96.
2. Fogleman, Ronald R., Gen, USAF, and Sheila E. Widnall, *Global Engagement: A Vision for the 21st Century Air Force*, Washington DC: Department of the Air Force, 1996.

General Hallin is presently the Deputy Chief of Staff, Installations and Logistics, at Headquarters United States Air Force, Washington, DC.

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Most Significant Article Award

The Editorial Advisory Board selected "Outsourcing—Determining the 'Hurdle Costs'," written by M. Alex Milford and Houston S. Sorenson, as the most significant article in Volume XXI, Number 2, of the *Air Force Journal of Logistics*.

Quickness Versus Quantity: Transportation and Inventory Decisions in Military Reparable-Item Inventory Systems

*Major Christopher J. Burke, USAF, PhD
Vincent A. Mabert, PhD*

Introduction

In the study of reparable-item inventory systems, one theory suggests that lowering the inventory stocking levels will have an adverse impact on the capability of the end items for which the system supports. The rationale supporting this theory is that to obtain the same level of capability at the reduced inventory levels, the repair process or the transportation segments of the reparable-item inventory system would have to be modified. This study investigates the interdependent logistics decisions of inventory and transportation in a military reparable-item inventory system.

A reparable-item inventory system is used for controlling items that are generally very expensive and have long acquisition lead times. Hence, it is more economical to design these items so that they are repaired after they fail, rather than treating them as consumable-items which do not receive any form of repair, but are disposed of after use. In this study the term "reparable" is used to identify a class of inventory items while the term "repairable" refers to the physical condition of an item. A standard military reparable-item inventory system consists of a repair facility (depot) dedicated to support several locations (bases) dispersed over an extensive geographical region where equipment (aircraft) is assigned. Over time, equipment malfunctions occur due to the failure of a specific item (avionics) internal to the equipment. A corresponding serviceable item is then obtained from an inventory location and installed on the malfunctioning equipment, thereby restoring it to full operational capability. The failed item is tracked as it is shipped to the repair facility, scheduled for repair, and subsequently shipped in a serviceable condition back to an inventory location.

The USAF is under great pressure to reduce infrastructure costs and lower workforce levels, while simultaneously maintaining the capability for air and space global engagement. Greater reliance on sophisticated avionics, reductions in the defense budget, and a smaller fighting force, both in personnel and equipment, form a precarious combination that the USAF must contend with now and in the future. This combination requires that USAF reparable-item inventory systems operate in a highly efficient manner with regards to their logistical structures, managerial decisions, and budgetary constraints. An effective reparable-item inventory system must not only provide the USAF with the ability to maintain the highest level of combat readiness, but must do so at an affordable cost.

Given these tremendous challenges that the USAF faces, this study seeks to investigate the interdependent logistics decisions of inventory and transportation through the following two research questions: (1) What amount and where should the item inventory be located in the reparable-item inventory system? (2)

What mode should be used for shipping the items in the reparable-item inventory system? Although these two logistics issues can be focused on individually, studying how they interact with one another provides a greater impact on understanding the overall military reparable-item inventory system and is the main thrust of this study.

System Description and Discrete-Event Simulation Model

The USAF McDonnell-Douglas F-15 (Eagle) air-superiority fighter aircraft is used as the example of a military reparable-item inventory system. The F-15 provides a solid representation of the reparable-item inventory systems seen in the military environment. The description of this reparable-item inventory system and its specific databases were obtained from USAF records provided by the F-15 System Program Office and the F-15 depot, both located at the Warner-Robins Air Logistics Center, Robins Air Force Base, Georgia. This reparable-item inventory system incorporates a two-echelon structure. The first echelon consists of six bases in the Continental United States (CONUS) separated into two geographical regions with three bases per region that have on-station anywhere from 48 to 72 F-15 aircraft. The second echelon consists of a single depot where all repairs are made to failed items; no repairs are accomplished at the bases.

The items tracked in this reparable-item inventory system consist of 14 avionics subassemblies considered essential for the F-15 to perform its primary flying mission. These 14 line-replaceable units (LRUs), ranging in value from \$20,000 to \$170,000, form a representative sample of the over 100 expensive LRUs used by the F-15. Each LRU contains subcomponents, such as circuit cards, which are defined as shop-replaceable units (SRUs). Maintenance to a malfunctioning aircraft is performed by removing and replacing a failed LRU at the base, while the LRU is repaired by removing and replacing a failed SRU at the depot—a two-level maintenance concept.

When an aircraft returns from a flying mission with a failed LRU, that LRU is removed from the aircraft and sent to a holding location on the flight line where it awaits shipment to the depot for repair. The most expedient method for a base to return this aircraft to Fully Mission Capable (FMC) status, that is, the ability to perform its primary flying mission, is to obtain a serviceable LRU from its servicing inventory location. If the servicing inventory location is located on the base and a serviceable LRU exists, then it is installed on the aircraft, returning the aircraft to FMC status. If, however, the servicing inventory location is not at the base, then the LRU must be shipped to the base. If a serviceable LRU does not exist at the base's servicing inventory location, then an unfilled aircraft demand exists and the aircraft

is considered "grounded"—unable to perform its primary flying mission. The repairable-item inventory system uses a one-for-one ($S - 1, S$) replenishment policy, which is a continuous review (s, S) policy where $s = S - 1$. The failed LRUs, which were removed from the aircraft and sent to the collection point on the base flight line, are shipped to the depot for repair on a daily basis.

The F-15 repair depot resembles an open job shop processing LRUs across identical parallel test-benches in a dynamic environment. The depot is constrained by the type and number of test-benches available for repairing LRUs, and therefore is a machine-limited system. Since this study incorporates a specific class of avionics LRU's for the F-15, the depot only contains test-benches, which are called Avionics Intermediate Stations (AISs). All 14 LRU-types are processed on three identical AISs, identified as the computer AIS. A first-failed-first-served priority repair scheduling rule is used to sequence the LRUs across an AIS. In this rule, the LRU in the depot repair queue that failed the earliest at one of the bases is scheduled next for repair. After an LRU completes the depot repair process, it is sent to the main depot warehouse where it awaits disposition for shipping to either the bases or inventory locations on a daily basis.

As stated previously, the most expedient means for a base to restore an aircraft to FMC status is by obtaining a serviceable LRU from its servicing inventory location. However, if the required LRU is not available at the base's servicing inventory location, then a stockout exists and an Emergency Lateral Transshipment (ELT), as defined by Lee, is initiated. (2) Slay identifies the use of "delayed lateral" transshipments, which are used when no inventory location can immediately fill an emergency lateral request, but in the future, an inventory location receives the needed LRU-type and can complete an ELT. (4) The repairable-item inventory system in this study uses the concept of delayed lateral transshipments.

The practice of removing a serviceable LRU from an aircraft that is already grounded because it lacks a different LRU, and placing that serviceable LRU into another aircraft that is grounded for that specific LRU, is known as cannibalization. Cannibalization is a maintenance management technique used to consolidate backordered LRUs to a single aircraft, thereby returning the other grounded aircraft to FMC status. However, the use of cannibalization is not a preferred method because it doubles the maintenance man-hours required to repair the aircraft and can induce malfunctions to an otherwise serviceable LRU through additional handling. Therefore, cannibalization is not modeled directly in this study, but is investigated in the additional analysis section.

The repairable-item inventory system described above is modeled using a FORTRAN based discrete-event simulation. (1) Using operational data for the aircraft, (aircraft flying hours and LRU failure rates) this study approximates LRU failures by a stationary Poisson process*. Since the repairable-item inventory

system fleet is large (360 aircraft), the failure rate is assumed to remain constant and independent with future periods. The fleet failure rate for the discrete-event simulation model used in this study is eight aircraft malfunctions per day for the system and it is assumed constant across all bases. In this study, 15 years is assumed as the LRUs' useful life period, which is representative of a military avionics system. At this point, an aircraft usually undergoes an extensive updating and modification of its avionics. The LRUs in this model never completely fail such that they cannot be made serviceable—no condemnations are possible.

Experimental Factors and Initial Inventory Levels

The two research questions developed have been further refined to identify the specific experimental factors and treatment levels to evaluate performance. The first experimental factor is inventory location. The three treatment levels of this factor are: (1) Inventory located only at the depot: inventory is consolidated and located at the depot. (2) Inventory located only at the base: each base stocks its own on-site inventory location with the required number of LRUs necessary to support its aircraft for their primary flying mission. (3) Inventory located only at the "queen bee" base: inventory is not stored at each base but is consolidated at a single base, identified as a queen bee base, within a geographical region. This queen bee base acts as the servicing inventory location for itself and the other bases in that geographical region. The logical choice for a queen bee base is the base with the most authorized aircraft in that region.

The second experimental factor, shipping mode, investigates commercial modes of transportation used to ship both failed and serviceable LRUs between the bases, inventory location(s), and the depot. All shipping in this repairable-item inventory system is conducted by private commercial carriers, like United Parcel Service or Federal Express. The two treatment levels of this factor are: (1) Shipping via ground mode (standard): all shipments are made via ground mode from origination to destination. (2) Shipping via overnight mode (premium): all shipments are made via overnight mode from origination to destination.

Associated with the first experimental factor, inventory location, is establishing the inventory level for each LRU-type. Determining the appropriate inventory levels for each LRU-type at each inventory location is complicated because LRU-types differ not only in their individual mean time between failure rates, which range from 200 to 30,000 hours, but also in their unit costs, which range from \$20,000 to \$170,000 per LRU. In this complex system, for a given specified level of system performance, a choice must be made as to which LRU-type should be increased, and at which inventory location. That is, increasing the inventory level of which LRU-type at which inventory location will provide the most "bang for the buck." A modified version of the marginal analysis technique employed by Sherbrooke is used in this study to determine the appropriate LRU inventory levels. (3) Sherbrooke's method uses probabilities to determine the expected backorders at specific inventory levels, $EBO(s)$, for each LRU-type. At each successive increase in the inventory level, the marginal decrease in expected backorders is calculated from the following equation:

* Interarrival times for a Poisson process are independent and identically distributed exponential random variables. This property states that there is a relationship between the (discrete) Poisson distribution and the (continuous) exponential distribution. Namely, Poisson probabilities for the number of demands (failures) in any period t are equivalent to an exponential distribution for the period between demands (failures). An alternate definition of this property is that if the time between demands has an exponential distribution, then the probability distribution for the number of demands in any specified period t is Poisson.

$$[EBO(s-1) - EBO(s)] / C$$

Equation 1

where, s = the inventory level and C = the LRU cost.

To determine the appropriate LRU inventory levels for the various reparable-item inventory system configurations in this study, a simulation based iterative process is used.

Primary Performance Criterion

The experimental factors and their treatment levels generate six alternative reparable-item inventory system configurations (three inventory locations and two shipping modes) which are investigated in this study. The primary goal of this reparable-item inventory system is to reduce the downtime for aircraft. Another way of stating this goal is to provide a specified level of system performance; a certain availability rate is used, previously identified as the FMC rate. This performance level is measured by the number of FMC aircraft at a base. The FMC rate is determined by calculating the number of aircraft available to perform their primary flying mission. The chosen level of system performance for this study is a target FMC rate of at least 85% for each base, which is representative of military standards for peacetime readiness.

However, in striving to obtain the specified level of system performance—a certain FMC rate—the economics involved in a reparable-item inventory system must also be considered. The total cost of this reparable-item inventory system is comprised of the initial investment in expensive LRUs and the commercial shipping costs associated with transporting both failed and serviceable LRUs. The commercial shipping costs are determined by a combination of the origination to destination distance and the shipping weight of the LRU. The costs for the bases, the depot, personnel, etc., are assumed to be sunk costs because the infrastructure of the reparable-item inventory system is already established. Holding costs, typically associated with inventory, as well as the depreciation and salvage values of the LRUs, are not calculated in this study. Therefore, the primary performance criterion is the total system cost that comprises the inventory investment costs and the shipping costs. The goal is to find the combination of experimental factors and their treatment levels that obtains the lowest average total system cost, inventory and shipping costs, while maintaining an average FMC rate at each base of at least 85% over a 15-year life cycle.

As described above, the total system cost is defined as the cost of the initial investment in LRUs plus the shipping costs associated with transporting both failed and serviceable LRUs and is given by:

$$\text{Total System Cost} = \sum_{i=1}^{n_i} \text{LRU Investment} + \sum_{y=1}^{n_y} \text{Shipping Costs}$$

Equation 2

where, i = LRU-type, y = year, n_i = number of LRU-types in the simulation model, and n_y = number of years the model is simulated.

Because the discrete-event simulation is designed to simulate 15 years of the model, the shipping costs are brought back to present value by means of a discounted cash flow technique. The technique used for the shipping costs is the single payment—present worth factor—that uses the basic compound interest formula defined as:

$$P = S \left[\frac{1}{(1+d)^{n_y}} \right]$$

Equation 3

where, P = the value of money at the present time (present worth), d = the discount rate expressed on a per annum basis, n_y = the number of interest periods (years the model is simulated), and S = the total cost of shipping for each n_y .

Results and General Observations

Table 1 ranks the six reparable-item inventory system configurations from lowest to highest based upon average total system cost. The first column identifies the particular reparable-item inventory system configuration while the second column provides an acronym for that configuration. The third column contains the average total system cost. The fourth column displays the percentage difference between the system configuration with the lowest average total system cost, DO, against the other five system configurations. Figure 1 presents the average total system cost for the six system configurations, illustrated by both the initial inventory and shipping costs. It should be noted that these results are a summation of a more detailed analysis. (1)

Reparable-Item Inventory System Configuration	Acronym	Average Total System Cost	Percent Difference
Depot - Overnight	DO	2,695,966	—
Queen Bee Base - Overnight	QO	2,761,869	2.44
Base - Overnight	BO	2,825,550	4.81
Base - Ground	BG	4,215,143	56.35
Queen Bee Base - Ground	QG	4,239,292	57.25
Depot - Ground	DG	4,716,907	74.96
Note: The Percent Difference is calculated with the DO system configuration as the baseline.			

Table 1. Ranking of Reparable-Item Inventory System Configurations by Average Total System Costs at an 85% Fully Mission Capable Rate

It is apparent from Figure 1 that the three reparable-item inventory system configurations with the lowest average total system cost all use an overnight shipping mode. The other three system configurations all use a ground shipping mode. One of the prominent results of this study is an insight into the ratio of shipping costs to inventory costs that comprise the total system cost. Figure 1 highlights the fact that those system configurations which use an overnight shipping mode have a very large shipping to inventory cost ratio. The inverse ratio is true for those system configurations that use a ground shipping mode. This situation

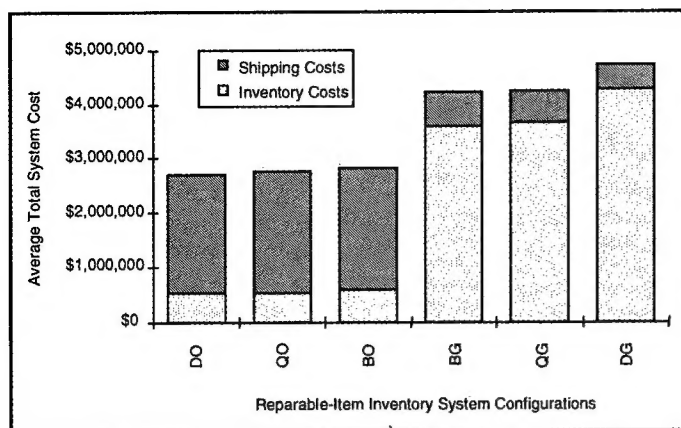


Figure 1. Average Total System Costs at an 85% Fully Mission Capable Rate

leads to the important concept of material quickness versus quantity. That is, if a system uses a quick shipping mode such as overnight, it does not require a large quantity of LRUs in the system inventory, thereby resulting in a lower average total system cost.

The idea behind material quickness versus quantity is that by shipping both failed and serviceable LRUs by an overnight shipping mode, the logistics pipeline is effectively "shortened." Hence, fewer quantities, or a lower volume, of each LRU-type are required in inventory for the system to meet a specific performance level. The opposite of this condition occurs when shipping quickness is reduced, as is the case for the ground shipping mode. In such a situation, the logistics pipeline is now effectively "lengthened" and a larger volume of LRUs in inventory is required to meet a specific system performance level.

Table 2 displays the percentage difference of the average total system costs between repairable-item inventory system configurations when differentiated by the shipping mode. The results illustrate that it is 49% to 75% more expensive to have a system configuration using a ground shipping mode as compared to using an overnight shipping mode. The concept of material quickness versus quantity is measured in terms of the average total system cost. In this study, the average per unit cost of an LRU-type is over \$50,000. Also, the overnight shipping cost for an LRU-type is on average 300% more expensive than the ground shipping cost. However, the results advocate that over a 15-year horizon, it is less expensive in terms of total system cost, to incur the more expensive overnight shipping costs, than to procure additional costly LRUs.

Ground Shipping Mode	Percentage Difference	Overnight Shipping Mode
DG	75%	DO
QG	53%	QO
BG	49%	BO

Table 2. Percentage Difference of the Average Total System Costs When Differentiated by the Shipping Mode at an 85% Fully Mission Capable Rate

Table 1 and Figure 1 highlight other general observations with regards to the experimental factors of inventory locations and priority repair scheduling rules. Within the three system configurations that use the overnight shipping mode is a pattern of where the inventory should be located in order of precedence:

the depot, the queen bee base, and finally at the base. These results suggest that inventory should be centrally located (consolidated) when an overnight shipping mode is used. The three repairable-item inventory system configurations that use a ground shipping mode display a different characteristic with regards to the inventory location. The results highlight the requirement to place inventory out into the system. That is, system configurations using a ground shipping mode should locate inventory with the following precedence: at the base, at the queen bee base, and finally at the depot. Because the ground shipping mode "lengthens" the logistics pipeline, it is important that inventory in the system, LRUs, be located as close to the sources in need of it (aircraft at the bases) as practical.

Additional Analysis

Varying Target FMC Rate

The main experiment used a target FMC value of 85%. However, there may be times when 85% is not the appropriate FMC value. This section investigates the average total system cost for two repairable-item inventory system configurations when different target FMC rates are pursued. Specifically, two system configurations (BO & BG) are tested with target FMC rates of 80% and 90%. Four additional simulations were run in the same manner as previously described, except that new inventory levels are calculated. Figure 2 displays the results of varying the target FMC rate. Focusing on the system configuration of BO, the results show that at a target FMC rate of 90%, the average total system cost increases by 60% from the value at the 85% target FMC rate. Conversely, there is a decrease in the average total system cost of 30% in obtaining a target FMC rate of 80%. When the target FMC rate is established at 80%, the purchase of additional LRUs is not required for the system inventory. That is, inventory costs are zero and only the shipping costs are computed into the total system cost. Focusing on the system configuration of BG, the results show that at a target FMC rate of 90%, the average total system cost increases by 53% from the value at the target FMC rate of 85%. Conversely, there is a decrease in the average total system cost of 51% in obtaining a target FMC rate of 80%.

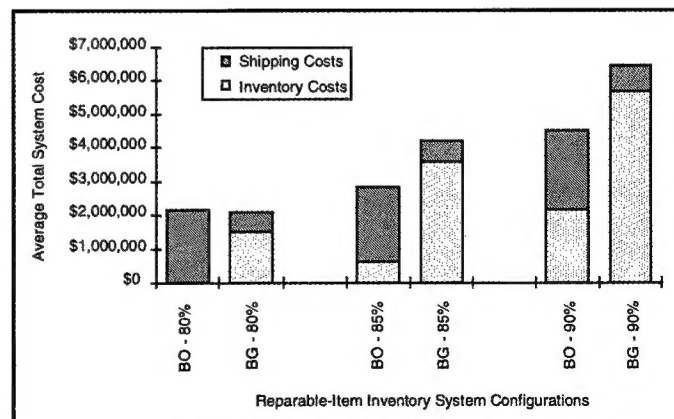


Figure 2: Inventory and Shipping Costs When Varying the Target Fully Mission Capable Rate

The results highlight that for target FMC rates of 80% or less, a system configuration which uses a ground shipping mode

provides a lower average total system cost than a system configuration which uses an overnight shipping mode. A trade-off point of 80% for this model has been identified. This result is because at these lower FMC rates, the cost of shipping carries a greater weight on the total system cost than does the cost of system inventory. Hence, a system configuration which uses a ground shipping mode will have a lower total system cost as compared to a system configuration which uses an overnight shipping mode. However, for target FMC rates above 80%, a system configuration which uses an overnight shipping mode provides the lowest average total system cost. This result occurs because at higher FMC rates, the cost of system inventory carries a greater weight on the total system cost than does the cost of shipping. Also, the results of this investigation illustrates how sensitive the average total system costs are to FMC rate changes. Average total system costs can increase by up to 60% or decrease by more than 50% when increasing or decreasing the target FMC rate by five points.

Varying Useful Life Period

The main experiment's useful life period for the items was 15 years. However, the useful life period of items may have a varying span in weapon systems. This section investigates the average total system cost for two reparable-item inventory system configurations when different useful life periods are pursued. Specifically, two system configurations (BO & BG) are tested with useful life periods of five and 25 years. Four additional simulations were run in the same manner as previously described at an 85% FMC rate. Figure 3 displays the results of varying the useful life period. The inventory costs for system configurations BO and BG are generally unaffected by the length of the useful life period. The change in the average total system costs can be attributed to the change in the shipping costs, which have been brought back to present value by means of a discounted cash flow technique. For both system configurations (BO & BG), the results show that at a useful life of 25 years, the shipping costs increase by approximately 37% from the values at the 15-year point. Conversely, there is a decrease in the shipping costs of 59% for a useful life period of five years.

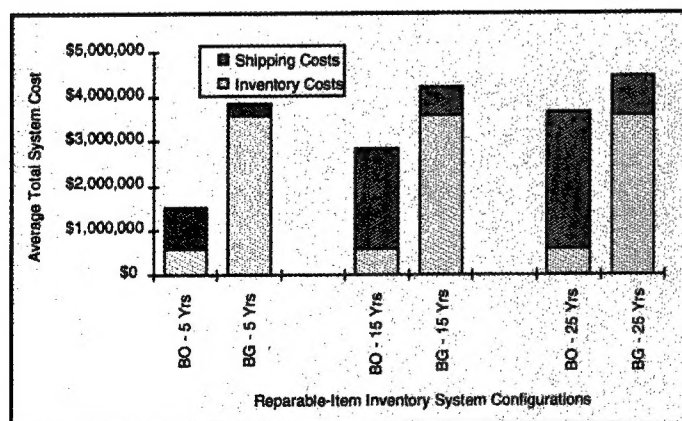


Figure 3. Inventory and Shipping Costs When Varying the Useful Life Period at an 85% Fully Mission Capable Rate

The system configuration of BO has the lowest average total system cost across all three useful life periods. At some useful life period greater than 25 years, BG will have a lower average

total system cost than BO. That is, it will be less expensive in terms of average total system cost to use a ground shipping mode than an overnight shipping mode. However, it is doubtful that avionics will continue to be effective in a weapon system beyond the 25th year, given the changes in the threat environment and technology. In fact, a strong argument can be made that in the future, the useful life period of avionics may be in the range of five years or less, due to replacement part obsolescence. The difference in the average total system cost between the system configurations of BO and BG is greater at the five-year point (152%) than it is at the 15-year point (49%). This result highlights that the shorter the useful life period of the avionics, the stronger the justification to use an overnight shipping mode based on the average total system cost.

Cannibalization

Although cannibalization is not a preferred method, some versions are used in practice. One particular version of cannibalization is to concentrate all cannibalization actions to a single end item. For example, one aircraft is identified as a "cann-bird" at each base and becomes a source for parts in which to cannibalize from in order to return other grounded aircraft at that base to FMC status. Such a use of cannibalization in this study is in essence, introducing one each of the LRU-types into the system inventory at each of the six bases. It is emphasized that LRUs removed from the cann-bird at a base are only used at that base and never sent to another base by an Emergency Lateral Transshipment (ELT).

Cannibalization is introduced into the system configurations of BG and BO which are exactly as previously described with the exception that one aircraft at each base has been identified as a cann-bird. These two system configurations are chosen because they represent the typical system configurations encountered in practice, providing a better benchmark for comparison. Table 3 displays the costs associated with the two different reparable-item inventory system configurations. The first row is the average total inventory investment required to meet an 85% FMC rate. The second row presents the average total shipping cost for failed and serviceable LRUs, with the third row showing total system cost. Table 3 also presents the percent difference between the average total system cost for each system configuration.

Average Costs	BG		BO	
	Regular	Cannibalize	Regular	Cannibalize
Inventory	\$3,579,503	\$905,655	\$595,621	\$0
Shipping	\$635,640	\$456,790	\$2,229,929	\$2,162,252
Total System	\$4,215,143	\$1,362,445	\$2,825,550	\$2,162,252
Percent Difference	68%		23%	

Table 3. Average Total Inventory, Shipping, and System Costs for BG and BO With and Without Cannibalization at an 85% Fully Mission Capable Rate

BO, which ships by overnight mode, required no additional inventory to be purchased for the system. Each base is able to obtain an average FMC rate of at least 85% through the use of the cann-bird and the responsiveness of the overnight shipping mode. The percentage difference between the BO system configuration when cannibalization is introduced is a cost reduction of 23%. The system configuration of BG, which ships

by ground mode, did require additional inventory to be purchased for the system, although at a lower quantity than when cannibalization was not used. The percentage difference between the BG system configuration when cannibalization is introduced is a cost reduction of 68%. The overall percentage difference between the two systems when both use cannibalization shows that BG has an average total system cost 37% less than BO. The use of cannibalization reduces the average total system cost for both BG and BO. In fact, cannibalization results in BG being less expensive in average total system cost than BO.

This finding is the opposite of what was identified for the main experiment. That is, the results show that with cannibalization, it is better (less costly) to use the ground shipping mode than the overnight shipping mode. Although BG has a higher inventory cost than BO, its total system cost is less because of the higher shipping costs incurred by BO in using an overnight shipping mode. It appears that cannibalization is an appropriate management technique to use in a reparable-item inventory system because of the reduction in the average total system cost. However, these cost savings predominately occur because with cannibalization not as many spare LRUs are purchased to stock the system's inventory. The cann-bird has in actuality, become an inventory supply point for 14 LRUs at each base. The cann-bird is an expensive form of stocking LRUs because an entire aircraft may be gutted for the purpose of supplying spare LRUs to other grounded aircraft. The costs of these LRUs are not recorded as additional purchases for the system inventory, but are masked under the purchase of an entire aircraft, whose cost is not accounted for in this study. Although the use of cannibalization helps in obtaining the target FMC rate at each base, it tends to hide the problem that the supply of spare LRUs in the system inventory is deficient.

Conclusions


This study investigated the interdependent logistics decisions of inventory and transportation for a military reparable-item inventory system. While this study utilized data from the USAF F-15 aircraft, the procedures and concepts illustrated here are applicable to other military reparable-item inventory systems. The results have furthered the understanding of reparable-item inventory systems, specifically the characteristics of a system when the combined logistics issues of inventory location and shipping mode are investigated under a monetary performance criteria. The shipping mode was identified as the most dominate experimental factor of the two factors investigated. The results indicate the best combination for a reparable-item inventory system is to consolidate inventory at the depot and use an overnight shipping mode. This combination leads to the lowest average total system cost for an 85% FMC rate over a 15-year period.

A concept of material quickness versus quantity was highlighted which advocates that using a rapid and responsive shipping mode, such as overnight, reduces the volume of spare items required in the system inventory to achieve a specific performance level. By choosing to ship items throughout the system quickly, the quantity of items, and their inherent expense, can be reduced in the system inventory. Although the overnight shipping cost for an LRU-type is more expensive than the ground shipping cost, this additional expense is offset by the reduction

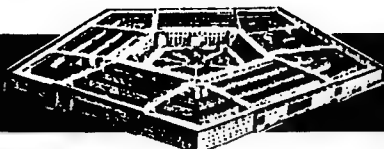
in system inventory costs, thereby reducing the total system cost. An additional benefit of reduced quantities of items in the system is highlighted when these items are identified for either modification or replacement. Because of the smaller quantity, not as many modification kits or replacement items would have to be procured to stock the reparable-item inventory system; a real benefit in these times of constrained budgets.

References

1. Burke, Christopher J., Capt, USAF, "Inventory Locations, Shipping Modes, and Priority Repair Scheduling Rules for Repairable-Item Inventory Systems," Dissertation, Indiana University, 1995.
2. Lee, H. L., "A Multi-Echelon Inventory Model for Repairable Items with Emergency Lateral Transshipments," *Management Science*, 33, 1987, pp. 1302-1316.
3. Sherbrooke, Craig C., *Optimal Inventory Modeling of Systems: Multi-Echelon Techniques*, New York: John Wiley & Sons, Inc., 1992.
4. Slay, F. Michael, "Lateral Resupply in a Multi-Echelon Inventory System," Report AF501-2, Washington DC: Logistics Management Institute, 1986.

Major Burke is presently an Assistant Professor of Logistics Management, Department of Graduate Logistics Management, Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology, Wright-Patterson AFB, Ohio. Doctor Mabert is a Professor of Operations Management, Department of Operations and Decision Technologies, School of Business, Indiana University, Bloomington, Indiana. 





USAF LOGISTICS POLICY INSIGHT

Deployment Policy

After nearly two years of development and coordination with the major commands (MAJCOMs), Air Force Instruction (AFI) 10-403, Deployment Planning, has been released to the field. This revision completely rewrites the initial publication of AFI 10-403, 10 June 1994, and provides much more detailed guidance. It formalizes the mandate for wings to use the Integrated Deployment System (IDS) and establishes the Wing Deployment Working Group to identify and resolve deployment problems, improve processes, and implement IDS.

War Reserve Materiel (WRM) Policy

AFI 25-101, War Reserve Materiel (WRM) Program Guidance and Procedures was published in October 1997. It provides stricter guidance on the use of WRM assets for other than major theater war requirements and adds more specific guidance on the Logistics Feasibility, Assessment, and Capabilities (LOGFAC) system, and WRM funding. It also sets stringent guidance on the use of Internal Slingable Units (ISU-90).

Base Support Planning

AFI 10-404, Base Support Planning (BSP), was recently published. It updates the two-part BSP process and provides clearer procedural guidance for the overall BSP program. A BSP Training Working Group will soon be established that will determine overall BSP training requirements.

(Col Carl Cafiero, HQ USAF/ILXX, DSN 227-8860, cafieroc@af.pentagon.mil)

Logistics Information Systems Standards

In order to reach the Air Force logistics community goal of developing a "seamless" logistics system, we must deploy information systems that are Defense Information Infrastructure (DII) Common Operating Environment (COE) compliant. Compliance with DII standards allows for early integration, commonality, reusability, standardization, and interoperability. The benefits of a COE include a common look and feel, promotion of a plug-and-play environment, and an enterprise-wide view of required information. The Air Force logistics community will be working with the Electronic Systems Command Logistics Information System Program Office (ESC/IL SPO) to develop the architecture that meets DII COE requirements and to modernize and integrate current stovepiped systems.

One example of a DII COE compliant modernization effort underway is the current fielding of the maintenance community's Integrated Maintenance Data System (IMDS). As IMDS is fielded in increments, it is scheduled to subsume over 200 information systems and will evolve into the standard maintenance management and data collecting information system supporting all weapon systems. It is critical that the Air Force

logistics and acquisition communities ensure that any other maintenance management information systems under development are compliant with the architecture under development by the ESC/IL SPO and do not duplicate capabilities provided by IMDS.

(Col Mike Howe, HQ USAF/ILXI, DSN 227-6939, hower@af.pentagon.mil)

Combat Support Doctrine News

The Air Force Doctrine Center (AFDC) recently convened the first semiannual Air Force Doctrine Working Group (AFDWG). Through the AFDWG, the Air Force approved development of a new Air Force Doctrine Document (AFDD) 2-4, Integrated Combat Support Doctrine. The new AFDD 2-4 will replace Logistics Doctrine (formerly AFDD 40) and integrate previously stovepiped doctrine encompassing all functional areas of combat support. The approval was in line with the recommendations of the August 1997 Air Force-wide Agile Combat Support Working Group, which met with representatives from the combat support functions from the MAJCOMs and Headquarters, United States Air Force. Another working group will meet sometime in the next few months to author the new publication. AFDD 2-4 will be the overarching operational level doctrine on how the Air Force provides combat support to its forces across the spectrum of military operations. Air Force combat support doctrine will use integrated processes as its foundation to be more operationally relevant to all Air Force units.

Air Force Basic Doctrine

AFDD 1, Air Force Basic Doctrine, has been approved and is on the Air Force Doctrine Center (AFDC) Home Page (<http://usafdoctrine.maxwell.af.mil/>). AFDD 1 replaces Air Force Manual 1-1, establishing general doctrinal guidance for the application of air and space forces in operations across the full range of military operations from global nuclear or conventional warfare to military operations other than war (MOOTW). AFDD 2, Air and Space Power Organization and Employment, is in draft and should be published in Spring 1998. It is the premier operational level description of how the Air Force transitions to contingency operations, organizes itself afield, and executes its assigned missions.

(Col Rick Comley, HQ USAF/ILXS, DSN 225-9830, comleyr@af.pentagon.mil)

New Training Policy Results in Maintenance Policy Review

An April 1997 change to the training policy eliminated the senior airman grade requirement for upgrade to the 5-skill level. This forced a review of Air Force maintenance policy. Air Force maintenance management personnel believed that, although an airman first class may have completed all the mandatory upgrade training requirements for award of the 5-skill level, in many

instances the individual may not have gained the necessary experience and technical expertise required for the responsibilities required as a production inspector. Therefore, in July 1997, AFI 21-101, Maintenance Management of Aircraft, was changed to require a production inspector to be in the grade of senior airman and above. However, recognizing the Air Force must make the best use of our qualified maintenance technicians, AFI 21-101 now authorizes group commanders to approve a limited number of selected 5-skill level personnel, in any grade, to serve as production inspectors for specific high volume maintenance tasks.

New Combat Air Forces' Maintenance Instruction In-Work

The Air Force has decided to draft an important new maintenance instruction specifically aimed at the Combat Air Forces (CAF). This new policy will ensure common maintenance practices throughout Air Combat Command (ACC), Pacific Air Forces (PACAF), United States Air Forces in Europe (USAFE), and the Air National Guard (ANG), and will further expand on necessary maintenance policy and guidance within the CAF. A meeting was convened at Langley AFB, Virginia, during the week of 3 November 1997 to formulate this new policy and draft the new instruction. Look for this important AFI to be issued in the upcoming months.

(CMSgt Timothy Breear, HQ USAF/ILMM, DSN 225-5266, breear@af.pentagon.mil)

JEDMICS Deployed at All Five Air Logistics Centers

The Air Force has successfully completed deployment of the Joint Engineering Data Management Information and Control System (JEDMICS) at Warner-Robins, Oklahoma City, San Antonio, Sacramento, and Ogden Air Logistics Centers. JEDMICS, a Department of Defense (DoD) standard repository for digital engineering data, has replaced the Engineering Drawing Computer Assisted Retrieval System (EDCARS), the Air Force's legacy engineering data repository. JEDMICS is a Continuous Acquisition and Life cycle Support (CALS) compliant system in that it will be interoperable with other DoD standard systems such as the Joint Computer-aided Acquisition and Logistics Support (JCALS) system. JEDMICS can manage a large spectrum of engineering drawing sizes and intelligent data formats. JEDMICS provides the means for Air Force product data users to efficiently convert, protect, store, manage, retrieve, and distribute digital engineering data. To date, all EDCARS legacy engineering drawings have been loaded into JEDMICS and, since JEDMICS has now successfully subsumed the functionality of EDCARS, EDCARS operations were concluded 31 December 1997.

JEDMICS enables on-line reference and research of, as well as makes possible global access to, approved engineering drawings. The new system also benefits the concurrent engineering process by allowing logisticians and engineers to access and manipulate digital copies of engineering data. Air Force JEDMICS users can now download multiple drawing images to their PC hard drives for storage, viewing, manipulating, and printing.

The Navy has joint program manager responsibilities for JEDMICS. The Air Force Product Data Systems Modernization (PDSM) Program Office at Wright-Patterson AFB, Ohio, serves as the Component Manager for JEDMICS implementation within the Air Force. Air Force JEDMICS information can be accessed via the Air Force PDSM Home Page at www.pdsm.wpafb.af.mil.

(Lt Col Rita Marshall, HQ USAF/ILMM, DSN 223-9836, marshlr@af.pentagon.mil)

Disposition of Unwanted Munitions: Development and Implementation of the Environmental Protection Agency's (EPA's) Military Munitions Rule

The Munitions Rule (MR) has its origin in the Resource Conservation and Recovery Act (RCRA) of the 1970s. Over the years, many Air Force functions have been affected (solvent collection on the wash rack, silver collection in the photo lab, etc.). In many cases, compliance was lax, but in 1992 the Federal Facilities Compliance Act (FFCA) put "teeth" in the compliance requirement. Notices of Violation (NOV) by EPA inspectors have resulted in fines and punishment.

As part of the FFCA, Congress directed EPA to develop regulations identifying when military munitions become hazardous waste and providing for the safe transportation and storage of such waste. Representatives from the DoD, the individual states, Indian tribes, and various environmental groups participated in EPA's multi-year effort to draft these rules.

The MR was published in the Federal Register on 12 February 1997 and was effective on 12 August 1997. Since the MR is a federal standard, not a national standard, state regulatory agencies retain primacy over its interpretation and implementation. To assure cooperative understanding of military munitions operations, the Deputy Under Secretary of Defense for Environmental Security (DUSD(ES)) sponsored multi-Service participation in a DoD, state regulator, tribal representative, and environmental group Partnering Initiative. This 26-member group visited a number of military facilities. These visits afforded DoD members the opportunity to show military attention to environmental details—and to better understand the environmental community's priorities and concerns.

Anticipating advent of the MR, the Joint Ordnance Commanders Group (JOCG) established a Munitions Rule Implementation Council (MRIC) in June 1996 to develop plans and to publish an "Interim Policy for Implementation of the MR." Working with DoD members of the Partnering Initiative, this interim policy was distributed to the MAJCOMs in March 1997.

One very important component of the MR is called Conditional Exemption (CE). CE is based on the premise that DoD Explosive Safety Board (DDESB) rules for military management of munitions affords a level of environmental control that is as good or better than RCRA. Visits to bases by the partnering group have served to reinforce this premise. The Services hope that individual states, as they implement the MR over the next two years, accept CE. If not, bases in the non-CE states will have to conform to RCRA rules.

DoD efforts to build confidence among the state members have paid off. Collectively the group developed a new waste

(Continued on bottom of page 33)

EXPRESS: An Overview and Application for Redistribution Decision Support

Ronald W. Clarke

Introduction

The Execution and Prioritization of Repair Support System (EXPRESS) is one of the primary systems supporting the PACER LEAN and Depot Repair Enhancement Program (DREP) processes. The main functions of EXPRESS are to identify customer needs, prioritize the needs, evaluate the feasibility of repair, and assist in driving the right items into repair. To perform these functions, EXPRESS essentially has complete reparable asset visibility throughout the supply chain. EXPRESS also has the internal analytical logic to compute priorities and discriminate between needs at different echelons and among operating bases. These characteristics suggest that an additional function can be incorporated into EXPRESS that can guide the logistics system into making good decisions on executing redistribution actions to satisfy priority needs. This article illustrates and starts to define the approach to a redistribution decision support capability within EXPRESS. The primary emphasis in the approach is placed on the requirement to support redistribution decisions involving high priority needs at an operating base or bases when no serviceable "excess" is available from other locations. A secondary application may be helpful for the general case where maldistribution exists when measured against the requisition objective (RO). In these cases, EXPRESS decision support can aid in deciding the most effective way to execute redistribution actions to correct the maldistribution.

The USAF's wholesale logistics system has been undergoing a process of significant changes during the past 36 months. This change has been related to the general principles of Lean Logistics, but led by changes to the process of organic depot-level repair embodied in the DREP. EXPRESS is one of the key information systems that support the DREP process. EXPRESS began with the same specific focus as DREP—the day-to-day execution of organic depot repair. As the change process of wholesale logistics continues to expand into new functions and processes, the demands on supporting decision information and automated capabilities continues to grow. EXPRESS is a logical system to target for expansion and support in this climate of continuous process improvement. This article suggests the area of redistribution is a function that can be improved by the data and logic inherent in EXPRESS. The details of the EXPRESS approach to support redistribution actions will be discussed after an overview of EXPRESS is presented.

Overview of EXPRESS

Background

EXPRESS has its technical origins in the earlier Distribution and Repair in Variable Environments (DRIVE) efforts that

revolved around the RAND Corporation developed DRIVE Model. (1,3) These efforts occurred in the late 1980s and early 1990. The significance of DRIVE was to introduce an aircraft availability based logic and capability for prioritization of repair and distribution at the depot level. In October 1995, EXPRESS was initiated as an Air Force Materiel Command (AFMC) reengineering effort in support of the Requirement and Distribution Reengineering Teams. A specified tool within EXPRESS was the DRIVE Model, which at that time was renamed PARs (Prioritization of Aircraft Reparables). In February 1996, the Senior Leaders' Materiel Course (SLMC) defined the DREP process in detail, and EXPRESS was one of the information system chosen for the DREP standard suite of systems. (5) PACER LEAN is the AFMC project that in June 1996, initially implemented DREP in ten shops across the five Air Logistics Centers (ALCs). EXPRESS was deployed and supported each shop in its implementation and operations for PACER LEAN.

Objective and Functions

The overall objective of EXPRESS is to provide automated system support to the DREP process. The primary sub-objectives, which support the overall objective, are as follows:

- Identify customer needs.
- Prioritize needs for repair and distribution.
- Assess repair supportability and identify constraints.
- Trigger automatic introduction of reparables into repair.

An overview of the EXPRESS functional architecture that relates to the sub-objectives is shown in Figure 1. A fundamental tenet of DREP is to repair only in response to an existing customer need. Therefore, the function of EXPRESS that identifies customers needs is critical to the process. As shown in Figure 1, the D035 and Readiness Based Levels (RBLs) are two categories of data on the input side of EXPRESS that relate to the customer needs functions. First, the D035 data inputs are comprised of on-hand asset information for the operating bases and the depot and requisition information from all customers. Second, the RBL establishes the amount of a particular asset (national stock number (NSN)) that each base is allowed to have in its inventory for peacetime operations. Other levels are reflected in War Readiness Materiel (WRM) details. EXPRESS identifies the needs that relate to operating bases by computing the difference in the total authorized levels (for example, peacetime operating stock (POS), WRM, etc.) and the actual on-hand assets. This result is often referred to informally as "RO holes." RBL also establishes for the depot a Working Level (W/L) target that is generally the amount needed for the depot repair pipeline. The depot needs are then identified as the difference

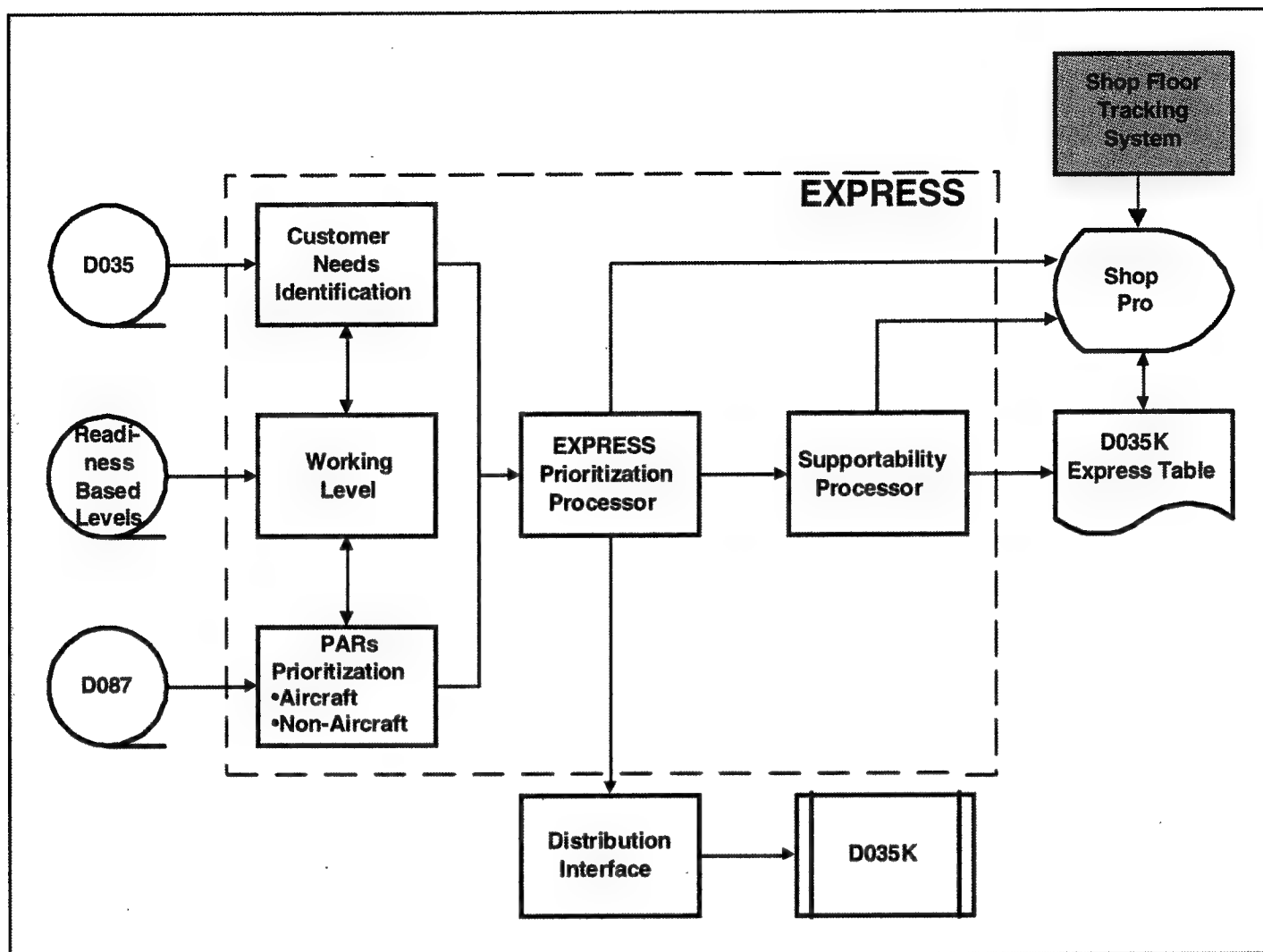


Figure 1. Overview of the EXPRESS Functional Architecture

between the W/L target and the on-hand assets in the repair pipeline. Finally, EXPRESS determines other customer (for example, Foreign Military Sales, other Services, etc.) needs by using the requisitions.

Once the needs are identified, EXPRESS then prioritizes the needs to facilitate decisions in downstream processes when constraints/bottlenecks are encountered that require resource allocation choices. PARs, with its underlying aircraft availability logic, is the primary tool used in EXPRESS for prioritization. The EXPRESS Prioritization Processor (EPP) supplements the PARs process when needed and performs the housekeeping functions related to prioritization. As shown in Figure 1, another major input to EXPRESS is D087 (DRIVE) which contains a wide range of item and factors information (for example, demand rates, quantity per application (QPA), not repairable this station (NRTS), etc.) as well as the weapon system goals and flying hour information. Priorities from this function are used as inputs to distribution and to supportability.

The portion of customers needs which represent a new introduction into repair are evaluated by the Supportability Processor within EXPRESS. This processor assesses the feasibility of each potential repair action in terms of four resource groups: (1) carcasses, (2) component parts, (3) labor hours, and (4) repair funds. Constraints are identified for further analysis

and action by other functions and processes within DREP. The repair actions which can be supported are identified for processing through the D035K Express Table process.

The D035K Express Table is the automated mechanism to get reparable items shipped from the warehouse or receiving dock to the repair shop. In the DREP process, EXPRESS provides the trigger to exercise the mechanism. The trigger is an automated system interface between EXPRESS and D035K whereby the supportable repair actions identified by EXPRESS are passed to D035K for processing.

Sample Outputs

Figures 2 and 3, on the following page, are shown as examples of EXPRESS output that illustrate the asset visibility and priority results. Figure 2 shows the status of authorizations and on-hand assets at the various operating bases (stock record account numbers (SRANs)). In addition to providing asset visibility, Figure 2 also shows how the base needs are determined. The highlighted column shows the final results of the needs computation.

Figure 3 is an example of the priority list for a national stock number (NSN). This list identifies a customer need by SRAN and each need is assigned a numerical priority referred to as a Sort Value. (2:26) The list depicts the needs ranked from highest

IM Code: N4V				NSN: 5831010103519				Control Number: 05193A				PSSD: MAPDL			
-----Base Needs Elements-----						-----Authorizations-----			-----Assets-----						
SRAN	Req Obj	Total O/H	+ MICAP	=	Base Needs (≥ 0)	POS Level	WRM Auth	HPMSK Auth	POS O/H	WRM O/H	DIFM	In Trans	B/O		
FB2037	53	49	0		4	11	41	1	4	42	2	1	6		
FB3010	0	0	1		1	0	0	0	0	0	0	0	1		
FB4810	10	6	0		4	1	9	0	0	5	1	0	5		
FB4833	23	24	0		0	3	20	0	4	17	0	3	0		
FB5000	12	5	0		7	5	6	0	0	0	0	5	6		
FB5270	8	4	0		4	2	6	0	0	4	0	0	4		
FB5411	0	3	0		0	0	0	0	0	0	0	3	0		
FB5685	2	2	0		0	2	0	0	2	0	0	0	0		
Total	108	93	1		20	24	82	1	10	68	3	12	22		

Figure 2. Example of EXPRESS Base Needs and Asset Information

NSN	SRAN	Sort Value	Kind Code	Comp Source
5831010103519	FB3010	2.01127048	09 COND A	PARs
5831010103519	FB2037	0.00347152	COND Z	PARs
5831010103519	FB5270	0.00118482	OWO	PARs
5831010103519	FB5270	0.00083458	OWO	PARs
5831010103519	FB5270	0.00058290	OWO	PARs
5831010103519	FB4810	0.00053175	OWO	PARs
5831010103519	FB2037	0.00042271	OWO	PARs
5831010103519	FB5270	0.00040351	OWO	PARs
5831010103519	FB4810	0.00033988	AWM	PARs
5831010103519	FB5000	0.00030430	COND Y	PARs
5831010103519	FB2037	0.00027683	COND Y	PARs
5831010103519	FB4810	0.00021489	Repair	PARs
5831010103519	FB5000	0.00019028	Repair	PARs
5831010103519	FB2037	0.00018823	Repair	PARs
5831010103519	FB4810	0.00014028	Repair	PARs

Figure 3. Example of EXPRESS Priority Needs List

LEGEND	
Auth - Authorized	O/H - On Hand
AWM - Awaiting Maintenance	OWO - On Work Order
B/O - Backorder	POS - Peacetime Operating Stock
DIFM - Due-In From Maintenance	PARs - Prioritization of Aircraft Repairables
HPMSK - High Priority Mission Support Kit	Req Obj - Requisition Objective
In Trans - In-Transit	SRAN - Stock Record Account Number
MICAP - Mission Capable	WRM - War Readiness Materiel
NSN - National Stock Number	

to lowest by sort value. The first priority with a sort value greater than 2.0 indicates that the need is a mission capable (MICAP), and illustrates the feature in EXPRESS that MICAPs receive the highest priority. The Comp Source field of the priority list

indicates that all priorities on this list were computed directly by PARs. The Kind Code field shows that the first 11 needs can be satisfied by assets already in the Working Level (for example, On Work Order (OWO), Awaiting Maintenance (AWM), etc.),

and the last four needs (that is, Kind Code = Repair) require a new introduction to repair.

As will be illustrated later in this article, the asset visibility of EXPRESS together with the priority logic, provide significant technical leverage and rationale for the applications of EXPRESS to redistribution.

Status of EXPRESS

EXPRESS continues to support the ten PACER LEAN shops. In addition, some ALCs have expanded DREP and EXPRESS to other shops, and the general plan appears to be to continue to expand on a shop by shop basis.

At the same time EXPRESS is expanding to other shops, the scope of its functionality is also being enhanced and expanded. For example, the financial interface between J025A* and EXPRESS was a significant enhancement implemented in July 1997. Changes to the priority scheme to implement the Logistics Board of Advisors' (BOA) priority release sequence are targeted for early 1998. Two other significant enhancements are in various stages of requirements definition. One of these enhancements will support the Contractor Repair and Enhancement Program (CREP), and the other is a Planning Function that will complement the execution portions of EXPRESS.

EXPRESS operates in a Windows NT environment with a SQL SERVER database management system. It is a client-server architecture with servers at HQ AFMC and each ALC. There are continuous improvements being made to the EXPRESS operating software and environment to make it more robust, reliable, and provide more automated capability for managing, processing, and updating data.

The current status and evolution of EXPRESS support the consideration of an expanded application and role in providing decision support for redistribution actions.

Redistribution Decision Support

As used in this article, the term "redistribution" is a process that moves serviceable assets from one retail location to another. This is in contrast to "distribution" which is a process that moves serviceable assets from a wholesale source of supply to a retail location. Redistribution actions normally occur for two general reasons: (1) to rebalance on-hand assets between users that have become misaligned (that is, maldistributed) when compared to the authorized levels, and (2) to satisfy a high priority need at one or more locations. There are ongoing changes in the D035 system to better routinely identify and execute the redistribution actions needed in the first case. The initial focus of EXPRESS in redistribution, as advocated in this article, is to satisfy high priority needs.

Objective and Scope

The EXPRESS redistribution objective is generally to use the computational logic and data within EXPRESS to support redistribution decisions.

The scope and boundaries of the approach to the objective are characterized by having the logic of the process internal to EXPRESS with an external interface to D035 for execution. The

approach will depend on data, which currently resides in EXPRESS, with one exception. This exception is the need to recognize the Joint Chiefs of Staff (JCS) coded units and type (that is, "A," "B," and "C"),* and the approach assumes this will reside in EXPRESS. Finally, a report function will be available in EXPRESS to view decisions related to redistribution.

Approach

The approach begins with a statement in the form of a question of the specific focus of an initial capability in EXPRESS related to redistribution. This question is: **How should assets be redistributed to satisfy high priority needs when no excess to base requisitions objectives (RO) exist?** The approach described and illustrated in this article attempts to be responsive to this question.

Several assumptions also are useful in describing the approach and are highlighted as follows:

- The criterion for a high priority need is a MICAP condition.
- Redistribution of assets excess to ROs has been accomplished.
- The presence of in-transits to a base offset high priority needs on a one-to-one basis.
- Any need for geographical considerations has been satisfied.

The definition of high priority need being a MICAP is noted but is not restrictive to the approach. Other criteria could be readily used if it can be translated into a sort value criteria. The second assumption influences the approach to the extent that conditions where excess exists will not be explicitly looked for or recognized in the proposed approach. The third assumption is consistent with PARs logic, but is offered for completeness and in consideration of default rules. Finally, the general approach does not explicitly consider any geographical constraints on redistribution. This will be discussed later in terms of potential refinements to the approach.

The overview of the approach is shown in Figure 4 on the following page as a four step process. The first step involves identifying the high priority needs and ranking them. This is a straightforward step in EXPRESS, since this information is inherent in the priority list which already exists in EXPRESS. The high priority needs criterion, defined as MICAPs (that is, sort values ≥ 2.0), can be readily applied.

Step 2 is a new step in the EXPRESS processing and is the main computational step in the approach. For each NSN that has at least one high priority need, this step involves performing a zero-based asset computation for all SRANs that are potential donors of this NSN. The potential donors are those SRANs which have on-hand assets and do not have a high priority need. The logic of the zero-based computation is to get PARs to prioritize the needs of the donor SRANs as though they had zero assets on-hand. For a particular SRAN, the array of sort values will be selected from highest to lowest and aligned with their on-hand assets. These sort values now represent the "value" of each

* JCS codes signify that the units have JCS operational tasking. The JCS code gives the unit a particular requisition priority. "A," "B," and "C" provides a level of priority shared-out between JCS coded units with "A" being the highest priority.

* J025A is the AFMC financial management system that certifies the availability of funds prior to the execution of repair for a particular item.

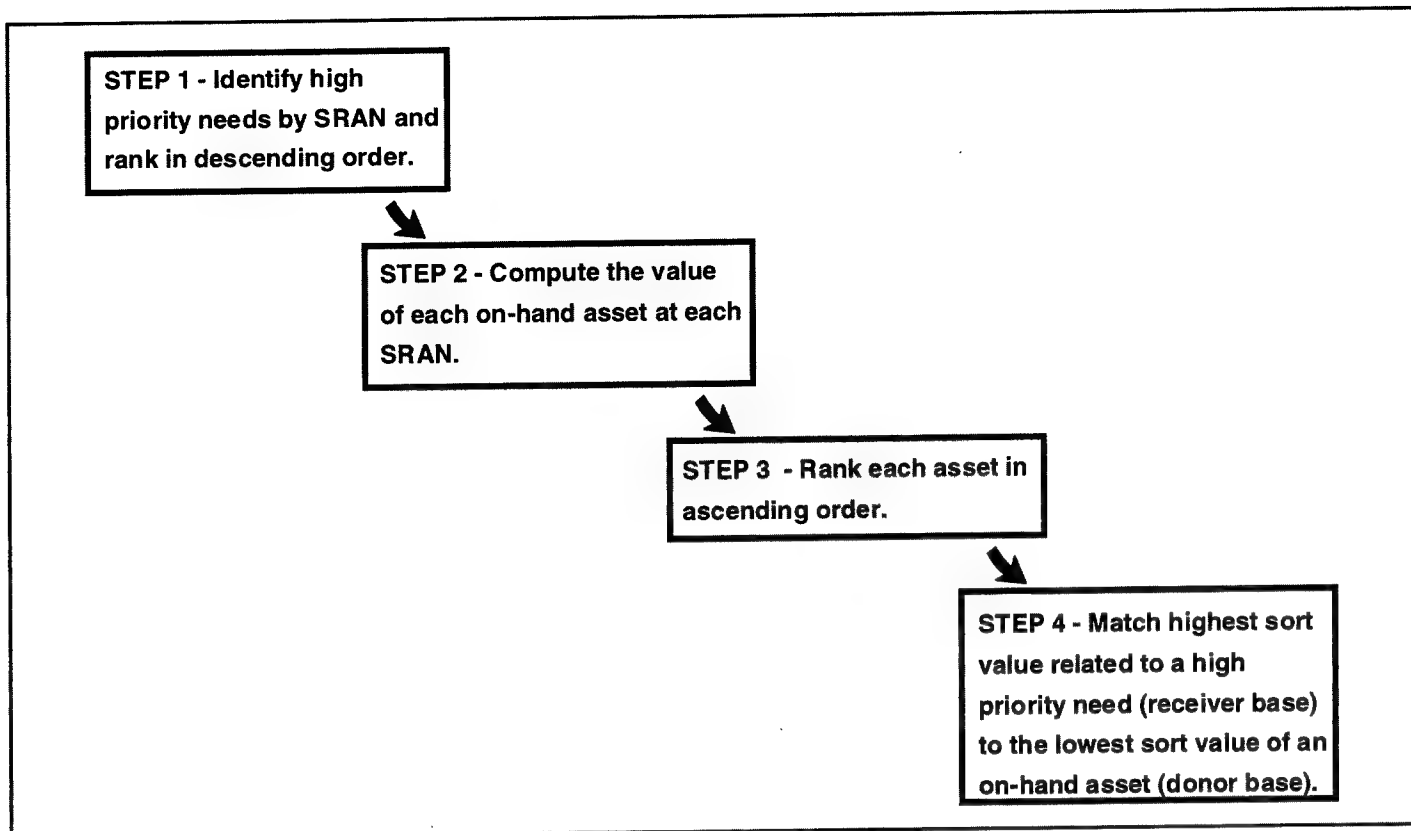


Figure 4. Overview of Approach for EXPRESS Redistribution for High Priority Needs

particular on-hand assets at that SRAN. Across all potential SRAN donors for an NSN, the lowest sort value represents the asset that can most logically satisfy the highest high priority need.

Step 3 is a process for sorting the sort values computed in Step 2 in ascending order for each NSN. This step will facilitate the

matching process that will occur in Step 4. This step matches the lowest priority value of a donor to the highest priority need.

Following is a hypothetical example to illustrate the four steps of the approach. Figure 5 summarizes the "input" information for the example. The left half of the chart depicts the beginning

NSN2345678901234BB					
SRAN	Priority of Need	SRAN	RO	On-Hand	MICAP
FB1100	2.0018076481	FB1100	2	0	2
FB2200	2.0016663485	FB2200	0	0	1
FB1100	2.0004282390	FB3300	6	1	0
FB3300	1.0003027863	FB4400	5	1	0
FB4400	1.0002069542	FB5500	9	8	0
FB1100	0.0311456389	FB6600	7	6	0
FB5500	0.0028769345	FB7700	8	8	0
.	.	FB8800	10	10	0
.	.	FB9900	8	7	0
.	.				
.	.				
.	.				
Priority List		Base Asset Positions			

Figure 5. Input Information for Redistribution Example

priority list from EXPRESS, and the right half shows the asset positions at the bases. Note that the priority list is not shown in its entirety.

Step 1 identifies the high priority needs by SRAN and ranks them in descending order. The results of Step 1 are shown in Figure 6.

STEP 1	
NSN2345678901234BB	
SRAN	Priority
FB1100	2.0018076481
FB2200	2.0016663485
FB1100	2.0004282390

Figure 6. Example of the Results of Step 1 of the Approach

Step 2 computes the value of each on-hand asset at each SRAN. This is the step where PARs is used to make a zero-based computation of the appropriate NSN/SRAN combinations. The results of the lowest eight sort values by SRAN for this NSN are shown in Figure 7. Results of Step 3 of the approach are show in Figure 8. Step 3 sorts the Step 2 results in ascending sort value order.

STEP 2	
NSN2345678901234BB	
SORT VALUE (On-Hand Asset)	SRAN (With No Excess)
0.0001977815	FB5500
0.0002383949	FB6600
0.0000739186	FB7700
0.0011244493	FB7700
0.0000178132	FB8800
0.0008209917	FB8800
0.0001155686	FB9900
0.0040301852	FB9900
.	.
.	.
.	.
.	.

Figure 7. Example of Step 2 of the Approach

STEP 3	
NSN2345678901234BB	
SORT VALUE (On-Hand Asset)	SRAN (With No Excess)
0.0000178132	FB8800
0.0000739186	FB7700
0.0001155686	FB9900
0.0001977815	FB5500
0.0002383949	FB6600
0.0008209917	FB8800
0.0011244493	FB7700
0.0040301852	FB9900
.	.
.	.
.	.
.	.

Figure 8. Example of Step 3 of the Approach

The results of the final step in the approach are shown in Figure 9 on the following page. In this step, the highest sort value related to a high priority need (that is, column 2) is matched with the lowest sort value of an on-hand asset (that is, column 4). The three arrows in the middle column relate the SRAN that will be the donor of an asset with the SRAN that will be the receiver of the asset.

The example illustrates the EXPRESS logic that identifies the redistribution actions. The next step in the overall process would be to send these actions through a defined interface to D035 for initiating and executing redistribution orders (RDOs) to move the assets.

Business Rules

The 61st Air Force Supply Executive Board (AFSEB) meeting provided guidance that represents some of the business rules which define the detailed functionality for redistribution as it applies to high priority needs. (4:5) In addition to defining a high priority need to be synonymous with a MICAP, other business rules are concerned with JCS coded units and non-JCS coded units. The rules are summarized as follows:

- RDOs can be made from any non-JCS coded unit to any other unit for a high priority need.
- The following apply to all non-JCS coded units (SRANs):
 - On hand assets can be taken to zero balance (including assets on detail (readiness spares package (RSP) balances)) to support an RDO for a MICAPs.
 - These units can be a donor to any other unit.
 - These units cannot be an RDO receiver from a JCS coded "A" unit.

STEP 4

NSN2345678901234BB

SRAN (With High Priority Needs)	HIGH NEEDS Sort Value		SORT VALUE (On-Hand Asset)	SRAN (With No Excess)
FB1100	2.0018076481	⇐	0.0000178132	FB8800
FB2200	2.0016663485	⇐	0.0000739186	FB7700
FB1100	2.0004282390	⇐	0.0001155686	FB9900
			0.0001977815	FB5500
			0.0002383949	FB6600
			0.0008209917	FB8800
			0.0011244493	FB7700
			0.0040301852	FB9900
			.	.
			.	.
			.	.
			.	.
RECEIVER			DONOR	

Figure 9. Results of the Redistribution Example

- JCS coded "B" and "C" units have the following rules applied:
 - "B" units can be a donor for any other unit up to 50% of assets by line item.
 - "C" units can be a donor for any other unit up to their last asset.
 - These units can be a donor for a JCS coded unit to a zero balance.
- JCS coded "A" units can only RDO to JCS coded requisitions.

Basically the rule is no donor base will RDO to a non-JCS coded unit if its resulting replenishment requisition is JCS coded.

In addition to these business rules concerning JCS coded units, other considerations may also be useful. The procedure to count in-transit serviceables to a SRAN as an offset to a high priority need should be explicit. Also, interpretation of the high priority designation for shop replaceable units (SRUs) causing awaiting parts (AWP) and requisitioned with a "6L" advice code* may also need to be clarified (that is, will the SRU requisition now be a MICAP when its line replaceable unit (LRU) is grounding a weapon system?). While the use of geographical boundaries (for example, Continental United States versus Overseas) for determining donor/receiver relationship may be too restrictive,

* The 6L advice code on a requisition signifies that the requisition is for an item (for example, SRU) that is causing an AWP condition in a higher assembly (for example, LRU).

the use of geographical boundaries for making the best response time and economic decisions may be warranted.

Other Thoughts

To apply the business rules associated with the JCS coded units, the system will need the visibility as to the unit and SRAN relationships of "A," "B," and "C" coded units. This information is not available in any wholesale system today. A suggestion is to designate EXPRESS as the wholesale system that maintains the identification of the JCS coded units. The functionality for the major commands (MAJCOMs) to provide inputs can be incorporated in the MAJCOM Scenario Subsystem where other unit information such as mission design series (MDS), primary aircraft authorization (PAA), and flying hours are maintained and provided.

While the approach discussed in this article deals only with decision support for satisfying high priority needs, there may be some further extensions that also have potential value. A similar approach could be applied to RDOs that involve redistributing assets excess to ROs. While the payoffs of applying decision support to this category of redistribution is less than the high priority case, it may still have value. Also, in some contingency situations, there may be a need for responsive support for making redistribution decisions for the purpose of increasing the readiness of selective units. Functionality could also be designed into EXPRESS to aid in these circumstances. Finally, EXPRESS

(Continued on bottom of page 23)



CURRENT RESEARCH

Air Force Research Laboratory Logistics Research and Development

Armstrong Laboratory was recently reorganized and is now the Air Force Research Laboratory (AFRL). AFRL, located at Wright-Patterson AFB, Ohio, performs a variety of research and development (R&D) for the Air Force. Logistics research is focused on how Air Force logisticians perform a number of different functions, maintenance of weapon systems, and logistics command and control. Supporting all Air Force logistics functions and major command (MAJCOM) directors of logistics, the AFRL is dedicated to applying advanced technology to essential logistics requirements, including such innovations as automated logistics job aids, maintenance diagnostics tools, and integrated product development advancements. Applications cover a broad spectrum of field, depot, and space operations with "customers" throughout the Air Force, Department of Defense (DoD), other government agencies, academic institutions, and US industry.

The following are brief descriptions of selected ongoing and future logistics research programs. The listing is current as of November 1997. Readers interested in obtaining more information about these programs or other logistics research activities should contact the respective program managers or visit the Logistics Research Home Page at www.alhrg.wpafb.af.mil.

AIRCRAFT BATTLE DAMAGE ASSESSMENT AND REPAIR (ABDAR) TECHNOLOGY

OBJECTIVE: Enhance ABDAR capability of the Air Force by providing battle damage assessors, technicians, and engineers with quick and easy access to assessment and repair information.

APPROACH: A contracted research effort began in August 1995 and will be accomplished in four major phases. In Phase I, a requirements analysis was performed to identify information required to assess damaged aircraft. In Phase II, the ABDAR demonstration system was designed, based on the requirements defined in the Phase I study. The design focuses on providing ABDAR information to the user through a portable maintenance aid (PMA). The PMA contains all of the information required by the user, including assessment and repair logic, technical orders, part information, wiring diagrams, schematics, and troubleshooting data. A graphical user interface allows the user to easily access and use ABDAR information. The Phase III effort, currently in progress, involves implementing the software design, authoring technical data, and integrating the system. Data for a specific test-bed aircraft is being developed for presentation on the PMA. Finally, Phase IV will involve final system enhancements and testing to evaluate system effectiveness and user acceptance.

EXPECTED PAYOFFS: Fast and accurate battle damage assessment and repair will lead to improved combat effectiveness by reducing the time to get damaged aircraft back to mission capable status. Less experienced users will have better access to

ABDAR information, reducing the amount of reliance on more highly trained assessors. Deployment capabilities will be enhanced by minimizing the amount of paper technical data and supporting information presently required by the user. (Capt Michael Clark, AFRL/HESR, DSN 785-2606, (937) 255-2606, mclark@alhrg.wpafb.af.mil)

APPLICATION OF MONOCULAR DISPLAY DEVICES (MDD) AND ALTERNATIVE COMPUTER CONTROL DEVICES (ACCDs) TO AIRCRAFT MAINTENANCE

OBJECTIVE: Assess promising new monocular display and alternative computer input technologies for the presentation and retrieval of maintenance technical information for flight line and depot maintenance.

APPROACH: A series of experimental studies is being conducted to evaluate how these devices could support various maintenance tasks. Initial efforts focused upon evaluating MDDs and ACCDs in a variety of environments. Current efforts focus on testing newly developed MDD and ACCD technologies. A variety of MDDs and ACCDs are being evaluated. MDD devices include occluding and see through displays. ACCDs include state-of-the-art speech-based controls and electromyographic (EMG) controls. EMG devices use electrical signals accompanying muscle contractions to input user commands. Seven studies and numerous usability evaluations have been conducted since 1991. The studies have demonstrated significant improvements in performance of technicians using MDDs under a variety of conditions and for a variety of types of tasks. Initial ACCD studies using speech recognition technology have demonstrated significant benefits to the technology, but have also identified problems encountered due to noise. Planned studies using advanced speech recognition and special microphones are expected to overcome this problem. This work is being conducted as a joint effort with the AFRL Crew Systems Interface Division.

EXPECTED PAYOFF: Improved maintenance performance, reduced maintenance downtime, and reduced maintenance costs. (Ms. Barbara Masquelier, AFRL/HESR, DSN 785-2606, (937) 255-3771, bmasquel@alhrg.wpafb.af.mil)

DESIGN EVALUATION FOR PERSONNEL, TRAINING, AND HUMAN FACTORS (DEPTH)

OBJECTIVE: Provide a tool to assess maintenance while design changes are relatively simple and cost-effective to make. Facilitate the logistics support analyses (LSA) process by automatically storing key support requirements data generated by the maintenance simulations.

APPROACH: On a new design, many problems can be detected only after an expensive physical mockup is built. By this point in time, it is often too late in the development process to make significant changes. Consequently, opportunities to reduce long-term costs, increase availability, and improve safety are missed. DEPTH will facilitate maintenance assessment during design by simulating tasks on "virtual mockups"

originating from computer-aided design (CAD) data. Using animated three-dimensional (3-D) models of humans, designers can analyze tasks in a variety of situations with respect to accessibility, visibility, and strength. Using accurate anthropometric and ergonomic data, DEPTH has the capability to simulate full maintenance tasks using advances in visual simulation. From simulation results, LSA records (personnel, tooling, task times, spare parts, and other relevant information) can be updated automatically. DEPTH was developed with input from the Air Logistics Centers (ALCs), industry, and the B-1, F-15, F-16, and F-22 system program offices (SPOs).

EXPECTED PAYOFF: The most significant cost savings come after a weapon system is fielded with streamlined repair procedures. Readiness is increased by ensuring removal and replacement of critical components is safe and not obscured. DEPTH can also reduce acquisition costs by providing an alternative to physical mockups and improving the LSA process. The simulations can be used by SPOs and ALCs to verify LSA data including safety, support equipment, hand tools, manpower, personnel, and training. The logistics data capture will cut costs by providing a direct link between the simulation and the LSA database. Animations from DEPTH can also be used for training and electronic technical manuals. (Mr. John D. Ianni, AFRL/HESR, DSN 785-1612, (937) 255-1612, jianni@alhrp.wpafb.af.mil)

DEPLOYABLE BARE BASE WASTE MANAGEMENT SYSTEM (DBBWMS)

OBJECTIVE: Develop and evaluate a deployable waste management system to support bare base operations.

APPROACH: The bare base waste management system will process the primary types of waste produced including municipal solid waste, medical waste, petroleum, fuels, waste water, and air emissions. It will consist of separate waste handling modules housed together on a pallet. Some examples of possible modules are: (1) a reactor to process municipal solid waste, medical waste, waste fuels, and other petroleum-based wastes; (2) a scrubbing system for exhaust gases that utilizes and evaporates waste water; (3) a reactor to treat black water solids; and (4) a containerization system for return of other wastes. The first phase of this work will consist of an 18-month systems optimization study to look at all aspects of the proposed system from an Air Force perspective. Power requirements will be analyzed, and operability factors, logistics impacts, and cost drivers will be examined. Users will be polled to determine operational requirements of the system, both from the technology itself and the logistics of deploying such a system. Engineering and life-cycle costing analyses will be performed for all possible technology candidates for each module and the overall system itself. Following this 18-month effort, the components will be integrated to form the waste management demonstration system. The resulting system will then be evaluated in a realistic operational environment, possibly at a Silver Flag Exercise site. This task is planned for completion by 2001. The work is being conducted as a joint effort with the Air Force Research Laboratory Airbase and Environmental Technology Division.

EXPECTED PAYOFF: This effort will demonstrate the feasibility of a DBBWMS which will provide a cost effective processing and neutralization of waste products produced during

bare base operations. Proper management of the waste materials will provide a safer, healthier environment for Air Force personnel, reduce the amount of cleanup required at the completion of operations, reduce environmental damage, and promote better relations with the host nation. (Ms. Jill Ritter, AFRL/HESR, DSN 785-3871, (937) 255-3871, jritter@alhrp.wpafb.af.mil)

DEPOT OPERATIONS MODELING ENVIRONMENT (DOME)

OBJECTIVE: Develop and test advanced process analysis technologies that will significantly improve the efficiency and reduce the costs of key logistics support processes in the ALCs.

APPROACH: A first-of-its-kind process engineering environment will be developed which will electronically link the operational wings and the depots, so that both can participate equally in process improvement efforts that directly affect them. This integrated environment will include a distributed collaboration capability, a modeling and simulation tool, and a process change impact analysis function. The collaboration tool will permit on-line interaction, across the country, in a variety of modes and applications. The distributed modeling and simulation tool will allow the users to jointly investigate the effects of process change scenarios. This will help reduce risks involved with the implementation of process changes by pretesting "to-be" alternatives in a simulation mode and comparing variables such as cost or probability of failure. The process impact analysis tool set will provide analysis of "as-is" and "to-be" models by identifying the impacts of proposed process changes on the organizational structures, roles, skill sets, training, and their interactions within the organization. A methodology for using the environment will also be developed. Plans are underway for installation and field testing of the system at Warner-Robins ALC, Georgia, and Mountain Home AFB, Idaho.

EXPECTED PAYOFF: DOME will provide the technology to perform smarter streamlining of logistics processes, resulting in improved ALC efficiency, productivity, and response time to the warfighter. (Capt Joseph J. Romero, AFRL/HESR, DSN 785-9940, (937) 255-9940, jromero@alhrp.wpafb.af.mil)

INTEGRATED REQUIREMENTS SUPPORT SYSTEM (IRSS)

OBJECTIVE: Enable more efficient and accurate definition, analysis, and management of weapon system requirements throughout the planning and acquisition processes.

APPROACH: IRSS is a response to the Air Force Directorate of Operational Requirements' vision of a "World Class Requirements Support System." MAJCOM participants have defined the IRSS functional requirements through joint application development sessions and spiral development. IRSS was founded on the results of exploratory research (Requirements Analysis Process in Design for Weapon Systems) and a study of the stand-alone unique systems designed to meet the needs of the creating command. The IRSS analysis objective is to exploit MAJCOM unique systems and develop a single, best practice tool set for Air Force-wide use. During Fiscal Year 1997 (FY97) an IRSS demonstration test bed system was developed and fielded at numerous user sites. During FY98, support will continue for further field testing, enhancement, and definition of production requirements.

EXPECTED PAYOFF: IRSS offers potential reduction in the effort needed to produce operational requirements documents that have Air Force-wide acceptance and visibility. IRSS is a common collaboration forum for the requirements community, and will provide an entry point for functional participants (logisticians, intelligence planners, etc.). IRSS also offers the potential to capture operational requirements as they evolve throughout the planning and acquisition cycle. The system will become a working application that generates official archives without additional effort. Lastly, IRSS has the potential to become a standard point of departure for requirements process innovations and will provide a suitable testing environment for innovative requirements management techniques. (Ms. Janet L. Peasant, AFRL/HESS, DSN 785-8502, (937) 255-8502, jpeasant@alhrp.wpafb.af.mil)

INTEGRATED TECHNICAL INFORMATION FOR THE AIR LOGISTICS CENTERS (ITI-ALC)

OBJECTIVE: Improve, standardize, and integrate technical and managerial information, and make it more readily available at the job-site to improve the performance of aircraft programmed depot maintenance (PDM) activities.

APPROACH: This effort has two phases. In Phase I, a detailed requirements analysis of current PDM operations at all Air Force ALCs was completed. The focus of Phase I was on PDM with a limited evaluation of assemblies, modules, and units. Information modeling was used to develop "as-is" and "to-be" functional, data, and process models that represent PDM operations and information requirements. Dynamic simulations were used to investigate process changes and improvements. Products from the Phase I effort include an architecture report documenting the results of a depot-level requirements analysis, a business case in which depot process improvements have been identified, functional specifications, and a top-level design for an integrated information capability. Phase I was completed in April 1996. In Phase II, the results of the requirements analysis phase are being used to design, develop, and test a demonstration-level integrated maintenance information capability for supporting PDM activities. Phase II activities will push the state-of-the-art by evaluating new diagnostic techniques, creating advanced techniques to improve the inspection process, employing new database approaches, and testing advanced hardware and software technology. Phase II started in December 1996 and will be completed by September 1998.

EXPECTED PAYOFF: The ITI-ALC effort will provide specifications for developing a full-scale, depot-integrated maintenance information system for operational use. In addition, this effort will provide the ALCs with an independent review of the current PDM process and possible changes or areas for improvement, to increase efficiency, lower operating costs, and improve technician performance. (1 Lt Pat Pohle, AFRL/HESS, DSN 785- 3871, (937) 255-3871, ppohle@alhrp.wpafb.af.mil)

LOGISTICS CONTROL AND INFORMATION SUPPORT (LOCIS)

OBJECTIVE: Provide logistics personnel at all levels within the wing-level complex proactive access to real-time accurate information needed for decision support and more effective utilization of logistics resources.

APPROACH: LOCIS is researching and developing technologies for an enhanced command and control capability for wing-level logistics personnel. LOCIS will provide easy access to logistics information to support proactive problem identification and resolution. LOCIS will automatically collect and synthesize information required for key logistics decisions. The most important pieces of information will be retrieved from existing maintenance, supply, munitions, and fuels information systems. Using advanced information technologies, LOCIS will automatically supplement this information with data from legacy information systems to provide immediate, useful information to logistics decision makers. In addition, LOCIS will use automated data collection technologies to supplement existing data with real-time data. LOCIS will use this information to provide logistics decision makers with a look-ahead simulation capability to identify problems in the planning/replanning process.

EXPECTED PAYOFF: LOCIS will provide logistics personnel the information and tools they need to better perform their duties. Through the use of real-time accurate information and the application of advanced decision aids, logistics personnel will be more effective in the day-to-day use of their assets and in short-notice deployment operations. (Capt Keith Shaneman, AFRL/HESS, DSN 785-3771, (937) 255-2606, kshanema@alhrp.wpafb.af.mil).

LOGISTICS CONTINGENCY ASSESSMENT TOOL (LOGCAT)

OBJECTIVE: Demonstrate new technologies and processes to improve the deployment planning process, reduce deployment footprint, reduce deployment response times, and use deployment resources more efficiently and effectively.

APPROACH: The Logistics Contingency Assessment Tool (LOGCAT) is a vision for improved wing level deployment planning and replanning. Currently, the LOGCAT Vision is comprised of four integrated initiatives, Survey Tool for Employment Planning (STEP); Unit Type Code Development, Tailoring, and Optimization (UTC-DTO); Beddown Capability Assessment Tool (BCAT); and Logistics Analysis to Improve Deployability (LOG-AID). STEP will use advanced integration of computer hardware and software to automate the collection, storage, and retrieval of deployment site survey information. STEP consists of three major subsystems: a suite of computerized and multi-media site survey data collection tools, a deployment site knowledge database, and a graphical and collaborative user interface for retrieving information from the deployment knowledge database. Transition of the STEP to the Standard Systems Group (SSG) for operational implementation is expected in early FY98. UTC-DTO uses advanced software to automatically develop UTCs, automatically tailor UTCs based on individual deployment scenarios, and optimize the packing of UTC equipment on to 463L cargo pallets. BCAT uses advanced database design to compare deployment site force beddown capabilities against deploying forces beddown requirements and produce a list of resource shortfalls. Transition of the BCAT to the SSG for operational implementation is expected in early FY98. LOG-AID is analyzing the deployment process firsthand to define requirements and identify additional opportunities to improve deployment planning processes. Where appropriate, additional planning tools and processes will be developed and integrated with the BCAT, STEP, and UTC-DTO tools to form

a demonstration deployment planning system. The demonstration deployment planning system will then be tested under field conditions.

EXPECTED PAYOFF: Improved wing level deployment planning and execution will increase Air Force combat capability. Reducing the mobility footprint will reduce requirements for scarce airlift assets, enabling deployment of additional combat capability. Reducing deployment response time will increase the deterrent effect of our military forces on distant enemies and allow policy makers to respond more quickly to aggressive actions of distant enemies should deterrence fail. More efficient and effective use of mobility resources will allow the Air Force to maximize its power projection capabilities. (Capt Joe Martin, AFRL/HESR, DSN 785-2606, (937) 255-3771, jmartin@alhrq.wpafb.af.mil)

MODULAR AIRCRAFT SUPPORT SYSTEM (MASS)

OBJECTIVE: Design, build, and demonstrate proof-of-concept aerospace ground equipment (AGE) that supply electricity, cooling air, nitrogen, hydraulic, and related utilities for aircraft maintenance in modular, multifunctional carts. Increase the affordability and reduce the deployment footprint of AGE through modular designs with advanced concepts and technologies.

APPROACH: The MASS program is supported through an Integrated Product Team (IPT) with members from the Air Force support equipment community and laboratories. The IPT will jointly develop requirements, provide customer input, coordinate R&D efforts, and manage technology transition for MASS. Phase I included a series of MASS design studies emphasizing technology assessment, cost and affordability analysis, and reliability and maintainability analysis of AGE. This early research resulted in a large knowledge base of existing problems and preliminary specifications for MASS machines. Phase II will bring this concept through a R&D cycle culminating in the creation of a MASS prototype unit and field test and demonstrations in FY00.

EXPECTED PAYOFF: Introduction of modular support equipment will reduce the deployment footprint in a direct, objective way. Making support equipment smaller, multifunctional, and modular allows for reduced numbers of ground support equipment items while maintaining flexibility. Maintenance modularity allows for reduced down time for repairs, increasing availability. At the same time, MASS machines will be more reliable and maintainable than current support equipment, resulting in reduced MASS ownership costs in manpower, spares, and training. Cost savings should span from initial acquisition through disposal. The goal is to reduce deployment footprint of AGE by 50%.

(Mr. Matthew Tracy, AFRL/HESS, DSN 785-8360, (937) 255-8360, mtracy@alhrq.wpafb.af.mil)

READINESS ASSESSMENT AND PLANNING TOOL RESEARCH (RAPTR)

OBJECTIVE: Develop and demonstrate innovative methods and tools to assist Air Force logistics agencies in the preparation, planning, and managing of organizational changes and process improvements.

APPROACH: This advanced development research program will assist logisticians and managers to successfully implement

changes in their organizations. First, the program will examine past change efforts, such as reengineering, Lean Logistics, and PACER LEAN, to understand organizational barriers to change. Second, the program will design an organizational survey that will identify these important issues to an organization and offer remedies to address them. Third, the program will build a tool that integrates the organizational assessment survey with a project planning function. The tool will enable an organization preparing for change to assess cultural, technological, and strategic issues within their organization. Based on the assessment data, the tool will offer suggestions on best tools and methods for that particular organization to utilize in their change effort. The tool will also contain a smart repository of lessons learned, both pro and con, from organizations that have been through similar change efforts in the past. Information in the repository will be utilized during the design of the "to-be" process to reduce risk, save time, and improve the quality of the results.

EXPECTED PAYOFF: RAPTR will assist Air Force users in achieving their process improvement goals by addressing the user's organizational culture, strategy, and technology issues. This tool will help users optimize their functional processes, resulting in dramatic improvements in critical performance measures such as cost, quality, service, and speed. The ultimate goal of RAPTR is to increase warfighting capabilities by streamlining logistics processes and reducing logistics costs. (Capt Cassie B. Barlow, AFRL/HESS, DSN 785-8363, (937) 255-8363, cbarlow@alhrq.wpafb.af.mil)

SUPPORT EQUIPMENT EVALUATION/IMPROVEMENT TECHNIQUES (SEE/IT)

OBJECTIVE: Analyze problems and determine potential solutions and technology shortfalls pertaining to aircraft support equipment (SE) in general, and aerospace ground equipment (AGE), in particular.

APPROACH: Interviews were performed with support equipment users and maintainers in the field, as well as other individuals responsible for purchasing and deploying support equipment. These interviews focused on defining problems associated with the reliability, maintainability, usability, and deployability of the equipment. Then requirements were gathered and analyzed on existing and near-term support equipment and weapon system technologies from industry and government sources. Finally analyses were performed to determine the optimum mix of support equipment modifications, technology insertions, and new procurements to provide the best payoff to the Air Force. The final product is a report and a database, which include recommended solutions for problematic equipment and suggested Air Force research candidates.

EXPECTED PAYOFF: The products of the SEE/IT program will provide reliability, maintainability, usability, and deployability benefits well into the future for operational units. SEE/IT provides a database of current support equipment problems and possible solutions. This will also help designers of future support equipment, such as the Modular Aircraft Support System (MASS) program, by acting as a lessons learned database.

(Capt Dwight Pavek, AFRL/HESS, DSN 785-9651, (937) 255-9651, dpavek@alhrq.wpafb.af.mil)

FUTURE RESEARCH AREAS

Logistics Research Requirements Survey and Analysis

This effort will survey base-level logistics personnel in all areas of logistics to identify needs and opportunities for research to improve logistics processes operations. Inputs will be solicited from a wide range of base-level logistics personnel, representing all levels of management and all logistics specialties. The goal is to identify those research opportunities that would provide technology that would most help the base level logistician, improve operational capabilities, and reduce operational costs.

Application of 3-D Graphics for Technical Information Presentation

The purpose of this effort is to develop and test 3-D technology as a means of facilitating the presentation and interpretation of graphical information used to support complex maintenance tasks. The study will examine multiple formats of 3-D graphics. The focus will be on graphic performance (user and software) and cognitive issues.

Application of Speech to Text Technology for Maintenance

The purpose of this task is to develop technology that supports both the ITI-ALC and ABDAR programs. The major challenge for voice recognition systems today is accuracy in adverse environments. Voice input facilitates hands-free operation of wearable computers, however voice recognition systems are not currently accurate, robust, or reliable enough to meet flight line user needs. Advances in voice recognition technology are still

needed in order to meet the high expectations of users. This task will focus on creating technology (hardware and software) that will improve the accuracy of voice recognition systems for form filling and computer control operations in support of flight line maintenance operations.

Transportation Systems Research

The purpose of this research area is to address numerous deficiencies listed in MAJCOM mission area plans requiring research of global distribution problems, materiel handling equipment deficiencies, war reserve materiel vehicle tracking, deployment footprint, support equipment and capabilities, and other transportation and mobility-related issues. The laboratory has established a Transportation Research Team to work with Headquarters Air Force Transportation, Headquarters United States Transportation Command, Headquarters Air Mobility Command, and others to develop a roadmap to address this vital research area.

Space Logistics

Like transportation, there are a growing number of space systems logistics-related deficiencies not currently being addressed by the R&D community. AFRL logistics is working closely with Headquarters Air Force Space Command and the National Aeronautics and Space Administration (NASA) to develop a roadmap to address common logistics requirements that could be addressed by the laboratory.

(EXPRESS: An Overview and Application for Redistribution Decision Support continued from page 18)

decision support could be useful in the process when RBL levels are updated to help re-level the inventory through redistribution.

Next Steps

This article is intended as an initial definition of a concept for providing decision support for redistributing to support high priority needs. If the concept is accepted and further activity is desired to evolve and mature the concept into a system capability, then the following steps are recommended:

- Allocate resources to expand the article into a requirements document.
- Coordinated potential interfaces and concepts of operation for execution with D035.
- Define a development plan.
- Make development and implementation decisions.

Summary

This article has presented an overview of EXPRESS. The attributes of EXPRESS related to asset visibility and prioritization logic provide valuable information that can be applied to a variety

of decision support needs. EXPRESS is particularly well suited to support decisions related to redistribution for the purpose of satisfying high priority needs. For this requirement, an integrated system solution appears to be a very feasible goal.

References

1. Abell, John B., et al., DRIVE (Distribution and Repair in Variable Environments): Enhancing the Responsiveness of Depot Repair, RAND Corporation, R-3388-AF, 1992.
2. Miller, Louis W., and John B. Abell, DRIVE (Distribution and Repair in Variable Environments): Design and Operation of the Ogden Prototype, RAND Corporation, R-4158-AF, 1992.
3. Moore, Richard, and Bob McCormick, Distribution and Repair in Variable Environments (DRIVE) Model Logic, HQ AFMC/XPS Working Paper 92-003, Sep 92.
4. 61st Air Force Supply Executive Board (AFSEB) Meeting, Minutes, HQ USAF/LGSP, 24 Feb 97.
5. Viccellio, Henry, Jr., Gen, USAF, et al., Senior Leaders' Materiel Course (SLMC), Briefing Materials, HQ AFMC, Feb 96.

Mr. Clarke is a Senior Systems Engineer at Dynamics Research Corporation, Yorktown, Virginia. **JL***

Is Your Organization Prepared for New Technology?

Captain Cassie B. Barlow, USAF, PhD
Allen Batteau, PhD

Introduction

In recent years the military has spent billions of dollars on information systems, yet still faces the challenges of streamlining workflow, improving data integrity, and achieving efficient communication. Information systems having superior technical qualities are often rejected or ignored by users. Some of the sources of resistance to new technology observed include the complexity and difficulty of the use of some systems and the loss of control or usefulness of old skills as new systems or capabilities are introduced. Introducing new technology also changes work relationships which can be another source of resistance.

One important dimension of the problem is human and cultural factors frequently impede the adoption of new technologies. Although this is frequently attributed to some innate "conservatism" or "resistance to change" which is supposedly part of human nature, in fact we know some individuals and groups can be highly innovative. It is more plausible to attribute both innovativeness and resistance to change less to innate human nature, and more to both the cultural background and the immediate context in which people find themselves. Some cultures are known to be highly innovative, while others are very resistant to change. Likewise, some individuals, no matter how open to change they are normally, in certain situations will become quite risk averse. In short, to the extent that culture and context can be understood and modeled in ways that are meaningful for technological innovation, a tool can be created that will assist the manager in overcoming the cultural and contextual resistance to change.

Culture can be defined as a historically evolving tradition of practices and beliefs that are uniquely shared by an entire group. In that any individual will belong to multiple groups, he or she will participate in multiple cultures and subcultures.

Context can be defined as the contingent situation of an organization or work group. Contextual features can include not only the physical infrastructure and the budget and program environment, but also the world diplomatic situation. For example, in times of crisis, some organizations become more innovative, or more willing to take risks.

Background

The Logistics Research Division of the Air Force Research Laboratory (AFRL) develops technologies to improve the logistics capabilities of the Air Force. One area of Laboratory investigation is the impact of new technology on logistics personnel and organizations, such as the introduction of information technology in System Program Offices (SPOs) and Air Logistics Centers (ALCs). In 1992, AFRL (then Armstrong Laboratory) created an initiative in Human Issues in Technology Implementation to understand these issues and develop tools and

knowledge that would support SPOs and ALCs in their efforts to adopt new technology. The objectives of this initiative were to:

- Define the domain and identify critical human impacts.
- Provide assessment methods for measuring these impacts.
- Provide systematic means to determine automation impacts, predict cost/benefit and success/failure, and produce guidelines for implementation.

The FRAME/WORK project was developed from this initiative. It was a Small Business Innovation Research (SBIR) project undertaken by Wizdom Systems, Inc., in cooperation with Wayne State University. Its purpose was to develop an understanding of the effects of USAF and Program Office culture and human issues on the implementation of advanced information technology, and make those findings accessible in a form that would be useful to Air Force Materiel Command (AFMC) management. The FRAME/WORK project identified the human, organizational, and cultural factors that impeded or facilitated the implementation of information technology in AFMC program offices and ALCs. The project then developed a software tool that would assist SPO and ALC managers in addressing these issues.

The FRAME/WORK project took an inductive approach, conducting complete cultural assessments of 11 SPO and ALC components. This inductive approach, guided by current research in human factors and socio-technical systems, produced results that are tailored to the needs and issues of AFMC. As contrasted to other studies that test hypotheses through field research, the FRAME/WORK approach concentrated on the discovery of socio-technical issues and patterns in AFMC. From this discovery it then developed both an assessment tool for examining different organizations and a set of issue reports and recommendations for managing the issues.

The intent of the FRAME/WORK project lay in *making social science work for management*—taking the most advanced results and methods of the social sciences, applying them in an AFMC context, and developing the results into a tool that would be useful for AFMC managers.

The tool envisioned was a *readiness assessment tool* with which a SPO or ALC manager could pinpoint the human issues that might impede the adoption of new systems within his or her organization. The tool approach was chosen as an alternative to a printed report or other medium, in the interests of the widest possible dissemination. An expert system was embedded within the tool that captured what was learned from fieldwork in SPOs and ALCs.

An empirical, inductive approach was chosen for building this tool. In the present state-of-the-art, there is no standard language

or variables for user readiness or organizational barriers to systems implementation. As an alternative to asking the SPO directors and Management Information Systems (MIS) managers about user readiness or their assessment tool requirements, users were asked about the issues that bore on their readiness to begin using new systems. This connection between human issues and technology implementation in the Air Force has been, in a systematic way, uniquely made by AFRL and the research, including FRAME/WORK, which it supported.

FRAME/WORK Development

The study that was conducted in developing the FRAME/WORK tool was an empirical study guided by the conclusions of numerous other studies of the interaction of human issues and technological systems. Synthesizing these studies laid an important groundwork for subsequent field investigations.

The background of the relationship between technology and culture is drawn from two related theoretical traditions: socio-technical systems theory, and human and cultural ecology. (12:20,8:126) Socio-technical systems theory (STS) provides a broad conceptual framework for thinking about the ways in which technological and human systems influence one another. Human and cultural ecology offer an approach to culture that recognizes the role of material artifacts (for example, technology—including local area networks (LANs), e-mail, shared databases, and document imaging) and the physical environment in shaping shared traditions of behavior and belief (culture).

The observation that technical and social subsystems are distinctive, yet interdependent, has significant implications for the management of technology in work organizations. One implication is that an organization cannot simply change one subsystem (for example, technology) and expect that subsystem to perform as it if were operating under laboratory conditions. (7:12) Another implication is that significant change in one subsystem (technology) always will require changes in the other subsystem if the technology is to operate optimally. (1:87) A third implication is that changes in either the technical or social subsystems of a work organization must recognize and accommodate the principles of both physical and psychological/social sciences.

This third implication yields the general principle of joint optimization, which states that the work organization should be designed or redesigned through mutual adjustment of both the technical and social subsystems. (15:5) Optimal performance in the work organization as a whole will be achieved when the needs and requirements of both the technical and social subsystems are considered and adjusted to fit each other, rather than attempting to optimize the performance of either the technical or social sides alone.

This project focused on technology deployment in AFMC subunits, within the context of the acquisition and logistics processes. Therefore, one logical approach to conceptualizing physical and cultural environments would be to use the internal patterning of the Air Force acquisition and logistics process itself as a framework for thinking about the effective environment. In the acquisitions and logistics process, new products pass through five broad phases, including:

1. Concept Origination.
2. Engineering Design.
3. Engineering Development and Testing.
4. Manufacturing.
5. Sustainment.

The specific features of the environment at various stages comprise environmental variables that influence the development of work group subcultures. These subcultures, in turn, influence the deployment of new technologies within the environment.

In the FRAME/WORK project, it was found that in some ecosystems, work groups responded to shifts by vigorous efforts to maintain the status quo (resisting technological change), while others responded by participating actively in the process of new technology adoption and implementation (thereby transforming themselves). A key goal of the analysis was to gain a better understanding of the factors and forces that played a role in shaping these two divergent types of responses to environmental change.

Conceptual Framework

The conceptual framework for this research began from the assumption work organizations are socio-technical systems. This means an understanding of the factors and forces that influence the deployment and implementation of new information technology must include an investigation of the psychological, sociological, and cultural properties of the work organization (the social subsystem), and the nature of interdependencies between these properties and the technical subsystem.

A second assumption that underpins the conceptual framework is the notion that the socio-technical system forms in part as a response to environmental opportunities and constraints. Thus, in seeking regularities across organizational subunits in responses to technology change (for example, adoption versus rejection of new technology), we must examine preexisting environmental properties and look for ways in which these properties are linked to regularities in socio-technical systems.

The exploratory research was aimed at identifying independent variables related to environments, and to properties of existing socio-technical systems (work groups), that might be regularly linked to the primary dependent variable (implementation or non-implementation of new information technologies). This early research identified several independent variables that held the potential to explain differences in work group responses to technology change.

Independent Variables

Stage in Acquisition/Logistics Process. This study's conceptualization of the environment suggests work groups may be located along a stage-process continuum associated with various phases of the acquisition/logistics process. Depending upon the phase in which a group concentrates its efforts, the physical and cultural environment of the group will differ. (3:202)

Volume of Paperwork. Many of the new information technologies under investigation are designed to manage the volume and flow of paperwork. It was reasoned therefore that work groups with a high overall volume of paper under their control might be interested in new information technologies that support paper management.

Resource Abundance or Scarcity. New information technology often is costly and represents a risk (since the payoffs are often unknown at the point of adoption). Therefore, groups with available resources should be more likely to invest in technologies with uncertain outcomes. (9:18)

Turbulence. Turbulence means the environment is changing in ways that are not controlled by the work group, and changes originating in distant locations disrupt operations at the local level, often without warning. (6:84) While new information technology may enable the work group to become aware of disturbances before they disrupt operations, turbulence sets up conditions that make new technology integration very difficult.

Supplier Environment. An important element in any organization's environment is the nature of other organizations that surround it, and with which it interacts. Relations between a focal organization and other organizations in its environment are one of the significant factors influencing the behavior of the focal organization. (2:60)

Air Force Culture. The cultural characteristics of the Air Force represent an important dimension of the cultural environment of the SPOs and ALCs that are adopting information technology. Characteristics of this cultural environment could influence technology adoption and use, or rejection, in a variety of ways.

Preexisting Technology Use. The existing technology utilized by a work group is an integral component of the group's "as-is" socio-technical system. This means the group probably has in place social subsystem elements that enable it to utilize the technology that is already present.

Organizational Structure, Fragmentation, Size, and Type. Work groups that display many internal boundaries will be incompatible with information technologies that seek to link groups horizontally. Organizational boundaries create subgroups that by definition have incomplete communication, sometimes leading to a lack of trust. (4:30)

Age of Organization. Stinchcombe discovered organizations bear birth marks from the era in which their structural form was invented. (11:32) Likewise, organizations adopt the technology current during their period of formation, simultaneously developing structures and cultures compatible with these technologies.

Occupational Prestige. Part of the informal organization of all work organizations is a status and prestige hierarchy among occupations, and units that house these occupations. (5:85) Prestige can influence the adoption of new technologies in a variety of ways. (13:25)

Discipline or Function. The discipline or function that is dominant in a work group can influence the technology-related behavior of individuals in the group. Discipline-based professions and occupations have subcultural characteristics rooted in the historical development of the discipline, and in the type of work performed by members of the discipline. (16:287)

Implementation Process. Research has shown organizations with a deliberate implementation process have far greater success at implementing new systems than those that simply load software and expect it to be used. (14:10)

In sum, the conceptual architecture embraced thirteen environmental and socio-technical systems variables. These were operationalized through an interview protocol, and their

association with levels of information technology usage, attitudes, and policies were examined at the different field sites.

Methodology

The core focus for this project was on the human and cultural factors in technology implementation. There is no standardization for these factors or issues in the literature, industry, or the military. Unlike performance issues in information systems, where there are standard measurements and benchmarks, there is no canonical statement of the barriers or readiness factors.

To understand these variables and develop measurements for the AFMC context, a field ethnographic approach was chosen, examining cultural patterns inside the 11 SPOs and ALC sites. The ethnographer—usually a solo practitioner—approaches the site naively, and immerses himself or herself in the setting. In contrast to a laboratory or survey approach, the ethnographer is observing behavior in a naturalistic setting; behaviors or beliefs that might be suppressed or hidden in laboratory or survey studies are revealed in the naturalistic ethnographic setting.

The goal in ethnographic research is the discovery and validation of these patterns of belief and behavior. Given the nature of the sample and the broad focus of the inquiry, the ethnographer is less concerned with statistical reliability or confidence intervals, and more concerned with meaningful patterns. The disadvantages of this approach are the dangers of insufficient depth in observation, yielding superficial patterns; the advantages are that when done well, with sufficient depth and discipline, the ethnographic report can communicate the multidimensionality of a given situation.

Scope of Investigation

The study focused on the implementation of seven specific types of systems within the SPOs. Three basic criteria were used to determine the information systems focus. The information systems had to be systems that:

1. Were visible to the user; focus was on applications rather than networks or operating systems.
2. Created new forms of connectivity and communication among users.
3. Required the alteration of work routines and patterns for their effective implementation.

Criterion 1 excluded LANs and mainframes. Criterion 2 excluded standalone applications such as word processors and spreadsheets. Criterion 3 excluded telephones and fax machines.

From the field investigation a set of management issues were derived. These formed an array of operational choices the SPO director, division, or branch chief can have some effect on, and thereby influence the readiness of his or her organization to adopt new systems.

The management issues utilized were:

- Technology Implementation Process.
- Training.
- Cultural Assumptions (Attitudes) About Computing.
- User Support and Diversity of Support Group.
- Levels of Usage of Computer Systems.

- Previous Experience With Computing.
- Technology Champions and Anti-Champions.
- Communication Among Coworkers.
- Funding.
- Job Design.
- Computer Literacy.
- Computing and Telecommunications Policy.
- Security.
- Organizational Barriers and Boundaries.
- Relationships with Contractors.
- Physical Access to End-User Devices.

After the set of management issues was created, recommendations for each issue were created. These recommendations were drawn from industry experience, Air Force experience, and literature reviews.

A critical issue in tool development was the mapping of the assessment results to the management issues. An indexing approach with numerical ratings on each issue was considered and rejected. This approach was rejected because of the extensive data that would be required to calibrate the indices. Based on the fieldwork results, assessment questions were mapped to the management issues, and each alternative response was assigned a probabilistic rating for the pertinent issue.

A report screen was developed to compare the manager's view on each of the seventeen issues with the users' view. In Figure 1, the thermometer on the right gives an overall rating of the organization's effectiveness in implementing new systems. The two-dimensional grid compares the manager's view of the issue (y-axis) with the users' view (x-axis). The issues are represented by icons. By clicking on an icon, the operator brings up a window summarizing the issue, with hypertext links to the recommendations.

Conclusions

The findings from this research in large part supported expectations. The thirteen independent variables are listed in Table 1 with the associated results as to their relationship with the dependent variable.

General conclusions from this research include:

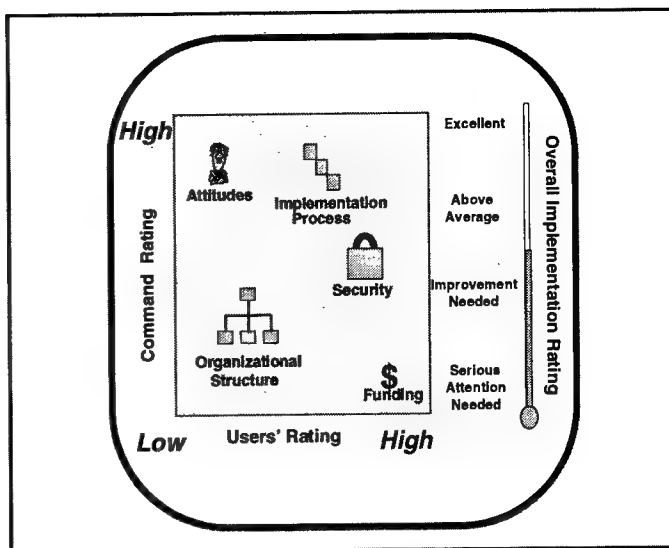


Figure 1. FRAME/WORK Report Screen

- General findings of patterns that, while observed at the SPO level of organization, have broader implications for AFMC systems implementation policy. These include the levels of implementation, the perceptions of levels of implementation, and the role of management.
- The external and internal SPO environments have effects on implementation. These environmental issues include program definition and infrastructure, which the SPO has some, but not exclusive leverage.
- Issues that bear on the socio-technical integration (how well a social system meshes with a technological infrastructure) of the SPO also effect implementation. The SPO director has significant leverage over these issues.

The FRAME/WORK project, and the AFRL Human Issues in Technology Implementation initiative that supported it, have created for the Air Force an important new view of how information systems are adopted and used. This view complements and improves upon other Department of Defense (DoD) and USAF initiatives, including the Continuous Acquisition and Life cycle Support (CALS) program, the

Guiding Hypothesis	Result
1. Effect of Program Stage	Supported
2. Volume of Paperwork	Insufficient Data
3. Stable Funding Promotes Adoption	Data Inconclusive
4. Turbulence Impedes Adoption	All System Program Offices Highly Turbulent
5. Poor Supplier Relations Impede Adoption	Not an Issue at User Level
6. Mission Critical Activities Less Interested in Information Technology	Insufficient Data
7. Effect of Installed Advanced Information Technology	Supported
8. Positive User Attitudes Promote Usage	Refuted
9. Basket System Program Offices Less Likely to Adopt	Supported
10. More Recent Organizations More Likely to Adopt	Supported
11. Organizational Prestige Affects Adoption	Supported, but Not Linear Relationship
12. Effect of Discipline	Appears to Have No Relationship
13. Implementation Plan	Supported

Table 1. Results of FRAME/WORK Study

Paperless Acquisition Initiative (PAI), Corporate Information Management (CIM), the Base Level System Modernization (BLSM) project, and AFRL's new programs, Readiness Assessment and Planning Tool Research (RAPTR) and Depot Operations Modeling Environment (DOME). The integration of the tools, methods, and insights of FRAME/WORK into these programs and initiatives will result in a far more effective and cost-saving utilization of information technology by the USAF.

AFRL is continuing this type of research in the Readiness Assessment and Planning Tool Research (RAPTR) program. Wayne State University, Wizdom Systems Inc., and Industrial Technology Institute, as the RAPTR contractor team, are developing a tool that will assess the readiness of an organization for implementing a change process. This tool will examine the cultural, technological, and organizational readiness of an organization embarking upon a change process (Lean Logistics, PACER LEAN, reorganization, etc). The tool will assess the readiness of an organization, offer recommendations, and assist the organization in planning and implementing the change process.

Summary and Impact

It is apparent through the FRAME/WORK proof of concept research and development program that culture should not be ignored when trying to implement a new technology in an organization. Major findings in this research and development project point out important facilitators and impediments to information technology implementation.

Information technology should be implemented aggressively in an organization. The rapidity of implementation correlates strongly with organizational usage levels. In addition, the more people who start using the technology at the same time, the more useful the information and communication technology tends to be. If only small numbers are hooked up initially, and implementation is slow, the initial users may discontinue their usage of the technology and share their lack of satisfaction with other organizational members. This reduces the likelihood of successful implementation.

Information technology implementation presents a management challenge in an organization. Active management resistance to office automation technology can hinder organizational attempts at implementation and usage, especially if the management is in a position to prevent implementation or usage. Management resistance can be overcome by a receptive overall culture and a computer support group that champions new office technology actively. In general, management viewpoints do not tend to correlate with organizational usage levels. Leadership is an important aspect of the implementation of office information and communication technology, but leadership in this arena appears to be more important if it comes from computer support personnel or from informal champions of technology change.

Extensive and intensive changes, or turbulence, in an organization and its support mechanisms have an effect on new office automation and communication technologies. Organizations that experience greater than average turbulence, especially if members perceived a high degree of association between organizational change and personal risk, are averse to technological changes. High degrees of turbulence also affected

the amount of time and energy available to cope with technological implementation and learning.

The age of an organization corresponds with usage levels. The older the organization, the lower the usage levels. This can be attributed to well-established practices of using manual techniques. Once manual techniques are perfected, and they have been proven successful in completing the required work, their use becomes ingrained in the culture, and it is much more difficult to change to automated office technology. If office communication and information technologies are implemented before manual methods have time to become entrenched, they will be received with less resistance and will be used more frequently. A young organization that waits to implement office automation technology is at risk of losing their advantage. Once manual methods are established and proven successful, it is possible to develop a cultural attitude of "if it ain't broke, don't fix it."

Whether someone can be persuaded to accept and use new office automation technology has more to do with their perceptions of other people's attitudes about the technology than it has to do with their individual attitudes about the technology. If people perceive a receptive office culture, they are more likely to accept and use new information and communication technologies, and the opposite is true as well.

A certain degree of fragmentation seems to be conducive to acceptance and usage of office information and communication technologies. When organizational members must cope with frequent temporary duties (TDYs), and/or the necessity of communication with remote locations (organizational members located out of state), this increases the likelihood of a high-usage level of communication technologies such as e-mail and video conferencing. In other words, collocation can actually hinder some implementations, instead of helping them. When people can simply push their chairs back and talk to each other (or communicate via the VLV—Very Loud Voice—method) they will be less likely to see the need for learning to use office information and communication technologies.

Perhaps the most important variable, with respect to the success or failure of office information and communication technology implementation, is the computer support provided before, during, and after the implementation effort. This is the key to creating receptivity, maintaining receptivity, and quashing resistance. The computer support group is responsible for the history of technological change, the change process, the change plans, and training.

Training is also important in the success of information and communication technology implementations. Just-in-time training is the most effective. Training too far in advance allows personnel to forget key information and training after implementation allows personnel to experience lack of usefulness, both of which are detrimental to receptivity. Furthermore, the training must be appropriate to personnel capabilities. If training is too basic, or too advanced, it will not be useful.

When the history of office automation technology implementation includes failures, it is much more difficult to implement subsequent systems successfully. Organizational members retain a memory of the past failures and are likely to expect this implementation effort to go the way of the other



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Logistics Professional Development

Logistics Cross-Flow Program: Alive And Well

The logistics cross-flow program was developed and implemented a little over two years ago. Since its development over 300 logistics officers have obtained training and practical experience in another logistics discipline. Over 22% of logistics captains have cross flowed with approximately 200 captains in cross-flow status at any given time. Some logistics personnel have questioned the program's viability. Despite what some may think, the logistics cross-flow program is definitely alive and well. The success of logistics cross flow lies with the primary facilitator of the program—the logistics group commander or senior logistician.

Although logistics cross flow has existed for over two years, the Air Force Personnel Center (AFPC) continues to receive many questions about the program from commanders and their officers. The following addresses the purpose, requirements, and commonly asked questions and concerns about the logistics cross-flow program.

Who and Why

The Air Force Logistics Officer Cross-Flow Program applies to captains in the following Air Force Specialty Codes (AFSCs): Aircraft/Munitions Maintenance (21AX), Logistics Plans (21GX), Space and Missile Maintenance (21MX), Supply (21SX), Transportation (21TX), and Contracting (64PX). The purpose of the program is to broaden the experience and enhance the performance of logistics officers throughout the logistics functions by attaining a minimum of two years consecutive experience in a second logistics discipline. The Logistics Board of Advisors mandated that cross-flow implementation be decentralized, and managed and conducted by the logistics group commander or senior logistician.

Experience in a Second Logistics Discipline

Experience in a second logistics discipline can be any combination of two logistics AFSCs (2XXX); any combination of logistics AFSC (2XXX) and contracting AFSC (64PX); and soon, (the Air Force Instruction (AFI) is currently in coordination) any combination of acquisition/sustainment and operational experience in a logistics AFSC (2XXX). Individuals with 24 months of documented Acquisition Professional Development Program (APDP), acquisition logistics, or program management experience, and officers awarded Special Experience Identifier (SEI) "LLA" for the Logistics Career Broadening Program (LCBP) will also receive "cross-flow credit" toward the fully qualified logistician AFSC (21L3/4) when the new cross-flow AFI is published.

Management and Requirements of the Cross-Flow Program

Logistics officers must attain at least four years experience in their initial discipline before they are eligible to cross flow into another logistics AFSC. There are two methods to cross flow: Permanent Change of Assignment (PCA) (intrabase) or Permanent Change of Station (PCS) (interbase). Both methods are controlled by the logistics group commander or senior logistician.

When selecting officers to cross flow via PCA, logistics group commanders or senior logisticians should consider the officer's time on station (TOS) or date eligible for return from overseas (DEROS) and strive for a one for one cross flow between the disciplines to maintain manning levels. Officers being considered for cross flow should have less than two years TOS (if in the Continental United States(CONUS)). AFPC can usually extend an officer for a maximum of four years to ensure qualification in the new discipline. DEROS extension requests may be approved by AFPC (as required) for officers overseas to ensure they become fully qualified in the second discipline. To facilitate the move, logistic group commanders or senior logisticians should coordinate their plan to PCA an officer into another logistics discipline with the Logistics Officer Assignment Branch (HQ AFPC/DPASL) prior to taking any action to move the officer into the new cross-flow position. This is necessary to ensure equitable manning levels across all logistics disciplines and the scheduling of the appropriate cross-flow bridge training. After coordinating the PCA, the unit submits an AF Form 2096 (Classification/On-The-Job Training Action) or PC III action to formalize the PCA. AFPC will assign an availability code 39 (assignment freeze code) to allow the officer to gain at least two years experience and become fully qualified in the new discipline.

The logistics group commander or senior logistician also manages the cross flow of officers via PCS by the special qualifications he or she designates in the advertisement. If the advertisement does not require the individual to be fully qualified in the advertised AFSC (usually annotated by an "M" for mandatory), this opens the opportunity for any officer to volunteer. An individual can find these ads on the Internet under the 21XX (Log XFlow) category. The AFPC Home Page uniform resource locator (URL) is <http://www.afpc.af.mil>.

Training

In order to fully qualify in a second logistics or contracting AFSC, an officer needs 24 months experience in the second AFSC and completion of the appropriate bridge and/or training course. Course slots are available through AFPC. The courses listed are available for the cross-flow officer.

Course	Course Number	Course Length/Location
Aircraft Maintenance Officer Course (Bridge – Prerequisite: Read Ahead)	SC 021A1	3 Volumes/Local Education Office
Aircraft Maintenance Officer Course (Bridge)	J3OLR21A1-008	4 Weeks/Sheppard AFB
Contracting Officer Course (Basic)	L3OBR64P1-000	6 Weeks/Lackland AFB
Missile Maintenance Officer Course (Basic and Bridge)	V2OLR22S1A-000	4 Weeks/Vandenberg AFB
Logistics Plans Officer Course (Basic and Bridge)	L3OLR21G1-000	4 Weeks/Lackland AFB
Supply Officer Course (Bridge – Prerequisite: Read Ahead)	L6OLU21S1-000	2 Months With Base Supply Training
Supply Officer Course (Bridge)	L3OLR21S1-000	4 Weeks/Lackland AFB
Transportation Officer Course (Bridge)	L3OLR24T1-000	2 Weeks/Lackland AFB

Frequently Asked Questions/Concerns

“Cross flow is a prerequisite to promotion; I have to get my second AFSC before I meet the board for major.”

- This is NOT true. Officers are promoted according to proven performance and their potential to succeed in the next higher grade. The bottom line is: do your best in every position you are assigned.

“Do I have to go back to my core AFSC after cross flow? I would like another tour in my cross-flowed AFSC.”

- In most cases officers return to their original (core) specialty. In reality, Air Force needs dictate future assignments and utilization. Each officer's background, and each career field's needs, will dictate the decision whether an officer returns to the core specialty.

“After I become qualified in two AFSCs, could I be selected for a nonvolunteer assignment in either AFSC?”

- Yes, an officer fully qualified in two logistics AFSCs could be selected for a nonvolunteer assignment in either AFSC. Vulnerability for assignment is based on many factors (qualifications, time-on-station, overseas or short tour return date, etc.).

Conclusion

The challenges facing logistics officers today are extremely complex and require an understanding of the interrelationships of all logistics disciplines. The logistics officer cross-flow program promotes the development of a solid logistics foundation that prepares our logistics officers for intermediate and senior logistics positions. The program has done well to prepare our officers through training and experience to be the logistics leaders of the future. The key to this success has, and will continue to be, the logistics group commanders and senior logisticians that have been challenged to groom our leaders of the future.

If you want additional information about the logistics officer cross-flow program or any other assignments issue, feel free to contact your AFPC assignments action officer listed below by phone, voice mail, email, or fax (DSN 487-3408) for assistance.

(Capt Marc F. Novak, HQ AFPC/DPASL, DSN 487-3556, novakm@hq.afpc.af.mil)

Civilian Career Management

Standard Automated Inventory Referral System

Significant changes are underway within the civilian personnel community which will impact the way Career Programs fill vacancies. Presently, the Air Force Career Programs use the Promotions and Placement Referral System (PPRS). PPRS referrals are based on the identification of people whose skill coded experience matches the skill codes of the positions being filled. The Standard Automated Inventory Referral System (STAIRS) will replace PPRS as the instrument used to identify candidates for referral.

STAIRS uses a commercial software package called Resumix, which matches individual knowledge, skills, and abilities identified on candidates' resumes to those required by the positions being filled. STAIRS, Department of Defense, and Career Program representatives are working to tailor this commercial package to Air Force applications.

In the near future, Air Force Civilians will be asked to participate in the development of the Federal Grammar Base by completing a resume, which identifies relevant employment experience, education, duties, etc.

(Jeff Allen, HQ AFPC/DPKCLR, DSN 487-4087, allenj@hq.afpc.af.mil)

Name	AFSC	DSN	E-Mail	Remarks
Lt Col Ed Hayman	21L, 21A	487-4554	haymane@hq.afpc.af.mil	AFELM, Pentagon, Joint
Capt Marc Novak	21A, 21M	487-3556	novakm@hq.afpc.af.mil	ACC, AFSPC
Capt Ray Roessler	21A, 20C0	487-3556	roessler@hq.afpc.af.mil	AMC
Capt Wes Norris	21A	487-3556	norrisw@hq.afpc.af.mil	AETC, AFMC, USAFE
Maj Debbie Elliot	21S	487-6417	elliottd@hq.afpc.af.mil	ACC, AFMC, AMC, USAFE, AFSPC, Pentagon, Joint
Capt Kevin Sampels	21S, 21A	487-6417	sampelsk@hq.afpc.af.mil	PACAF, AFSOC (21A and 21S)
Capt Ken Backes	21T	487-4024	backesk@hq.afpc.af.mil	All 21T Positions
Maj Rick Sullivan	21G	487-5788	sullivanr@hq.afpc.af.mil	AETC, AFSOC, AFSPC, AMC, USAFE
Capt Keith Quinton	21G	487-5788	quintonk@hq.afpc.af.mil	ACC, AFMC, PACAF, Pentagon
Maj Dan DeMott	64P	487-3566	demottd@hq.afpc.af.mil	All 64P Positions

INSIDE LOGISTICS

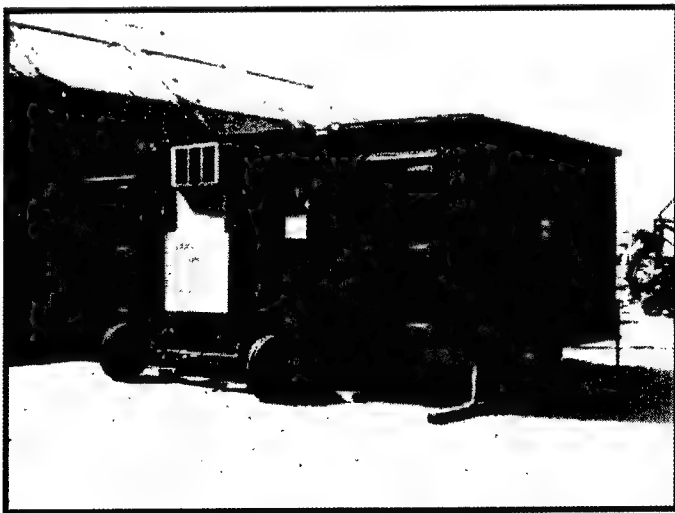
EXPLORING THE HEART OF LOGISTICS

Falcon Fixer

Second Lieutenant Ryen S. Hitzler, USAF

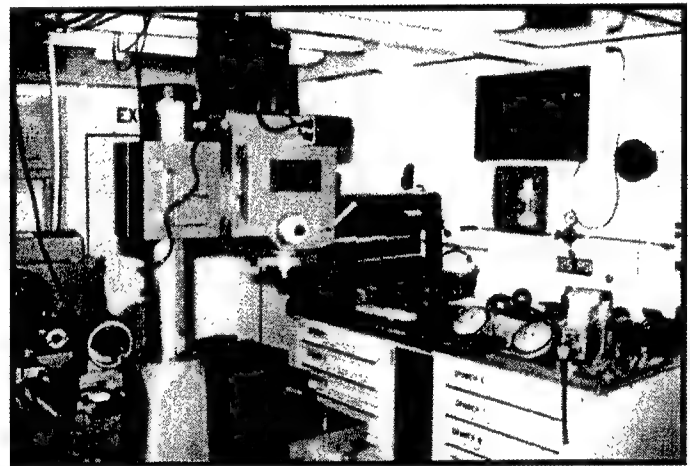
The "Falcon Fixer" is a mobile aircraft repair facility which was conceived by people from Hill AFB during the conflict in Southwest Asia. Their innovative conception made a substantial contribution to the 388th Fighter Wing's (388 FW's) ability to conduct combat operations and sustain combat sorties at a front line location.

The Falcon Fixer is a reconfigured mobile FS-7 photoreconnaissance trailer we acquired through the Defense Reutilization and Marketing Office (DRMO). This trailer is expandable to approximately 200 square feet, and rests on a four-wheeled undercarriage. For ease in airlift and towing behind a prime mover, the trailer contracts to the size of two and a half 463L pallets. The trailer contains a comprehensive workstation for metals technology and structural repair, consisting of a gear-head milling machine, lathe, grinder, arbor press, equipment for tube manufacturing, and supplies for 90 days. Non destructive inspection (NDI) is equipped with a joint oil analysis machine and other equipment to sustain all NDI functions, with the exception of X-ray. Additionally, the Falcon Fixer has fixed tool bins, tables, and shelves accommodating several of the individual workstations.



How does the Falcon Fixer fit into our mission? The mission of Air Force combat units is to first control the air, then sustain

air superiority. The 388 FW uses the Falcon Fixer to ensure we keep our instruments of war, 54 F-16 Fighting Falcons, flying from a bare-base location for prolonged periods. The Falcon Fixer is so well equipped it can support the completion of full phase inspections and manufacture almost any aircraft part that can be made or fixed back at our home station. Maybe equally important, it is equipped with a 12.5-kilowatt generator, air compressor, and heat pump. These essential pieces of equipment can be used by both the troops in the Fabrication Flight and other shops while supporting the generation of combat sorties.



The Falcon Fixer is a moneymaker. As you may imagine, it has the potential to save the Air Force far more than its material cost. This mobile platform brings many logistical options to the commander. The mobile nature of the Falcon Fixer allows it to be moved to where the work is being done, greatly cutting down on the distance traveled by maintainers. Additionally, it is capable of supporting any aircraft in the Air Force inventory, and can easily be used by wings operating multiple type fighters and support aircraft. The ability to repair an aircraft at the forward operating base as opposed to a rear base is a great benefit. This enhances a commander's span of control, and significantly reduces the down time of our limited front line fighters.

The Falcon Fixer demonstrated its ability to keep our fighters flying when an F-16 fuel flow proportioner bracket broke in Kuwait. The Falcon Fixer's unique metal working machinery allowed the repairs to be accomplished at the forward operating location, and the jet returned to fly combat sorties. This saved over 72 hours down time that would have been required to have the part sent away for repair.

On another occasion, the Falcon Fixer was deployed to Bahrain on short notice when six of our deployed aircraft were grounded for chafed hydraulic lines. The deployed maintainers had limited access to the Bahrainian maintenance facilities and their deployed tool kits lacked tube manufacturing capability. Amazingly, all six of the aircraft were repaired within 12 hours of the Falcon Fixer's arrival at Bahrain.

The Falcon Fixer has proven itself in both real world deployments and exercises. Twice it has been deployed in support of our commitment to the stabilization of Southwest Asia. The first such deployment was to Kuwait in support of Operation SOUTHERN WATCH from July 1995 to October 1995. During this demanding deployment, the Falcon Fixer was manned by metals technology, NDI, and a structural repair troops maintaining 16 F-16s. More recently, it deployed to Bahrain supporting 17 F-16s from October 1996 to December 1996, also in support of Operation SOUTHERN WATCH. The 388 FW depends on its repair capability, and we train how we fight, using them during every Operational Readiness Inspection and Evaluation. The troops enjoy using their own creation and have a great deal of "pride in ownership." The bottom line is, the capability and flexibility of this unique repair facility greatly enhances a commander's ability to maintain fully mission capable (FMC) aircraft.

What did we do before its creation, and what do other fighter wings use to maintain front line fighters? Our wing, like most wings, relied on rollaway bins when deployed. These bins would be placed on pallets and off loaded at their designated location. Once there, the maintainers searched for a structure to work out of and hoped they would find advanced machinery to repair their jets. It was accepted that major repairs, or complicated machinery work, meant sending the jet or part away for repair, and have the fighter return to flying combat sorties at a later time. The Falcon Fixer not only gives the maintainers a environmentally controlled work center, but they are supported with state-of-the-art equipment that is very close to what they work with at their home station, and may rival that of any other location in the theater of operation. The combination of its ability to move to where the work is being conducted, or away from harm, and its advanced tooling give the wing a significantly greater flexibility than the older system of roll away bins and tool boxes.

Have we experienced problems? Several problems have crept up on us over the past year. One problem was bringing the units to a serviceable condition. They had been neglected for years and several man-hours were required to get them to their current

war ready condition. On a recent deployment, one was loaded onto a C-5 cargo aircraft and one of the axles collapsed due to an improper loading method. To solve this, all of the axles were beefed-up and clear instructions were documented for configuring the unit for airlift. A management problem we experienced was keeping the Falcon Fixers fully stocked and equipped at all times. The problem arose during an operational readiness evaluation where we used the Falcon Fixer and its supplies. We needed to fix a "flyer" aircraft on the flight line, and the only place we could get the operating stock on base was in the Falcon Fixer. This problem has been solved by locking it and establishing a policy that it is to remain 100% mission capable at all times. When we do need to get into it, flight supervision will ensure the Falcon Fixer is the last resort and the item removed is ordered immediately. These problems were small, and staying on top of management discipline, and preventive maintenance, have made them easy to overcome.

What is the future of the Falcon Fixer? I hope they will never be used for their designed purpose; to support the comprehensive maintenance of front line fighters for an extended campaign, while deployed to a bare base location. We currently have two Falcon Fixers, one desert camouflaged, and the other forest camouflaged. Our vision is to continue to upgrade them by adding welding capabilities and more supplies. Advertising our unique capabilities of a reliable supply of 110-volt electricity and compressed air to other deployed shops is a renewed interest. We see this mobile aircraft repair facility becoming more widely used by front line fighter units. This could lead to a smaller logistical footprint with greater maintenance capability.

The concept of a Falcon Fixer was born from the experience in Southwest Asia by those who served there. Several members from the 388th Maintenance Squadron Fabrication Flight, began looking at a way to make a "War Wagon" due to the need for added maintenance capability, a work center, and mobile platform. Soon after, others expanded on the idea and each worked on a different component. Ideas were incorporated, and excitement grew as the idea of a War Wagon grew into the Falcon Fixer that sits ready to deploy today. They are a testament to good people allowed to come up with great ideas to help themselves wage war, and the wing to commit combat ready F-16s to fly, fight, and win!

Second Lieutenant Hitzler is presently the 388th Maintenance Squadron Fabrication Flight Commander at Hill AFB, Utah.

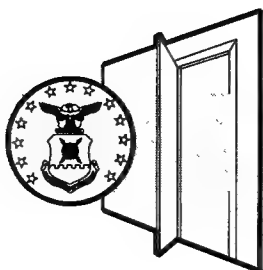
(USAF Logistics Policy Insight continued from page 11)

storage standard for incorporation into DD6055.9, the DDESB Standard. This "gap filler" will be provided to the DDESB Secretariat and is expected to be voted on at the January 1998 meeting of the DDESB Board.

The partnering group also has been working on an update of the March 1997 Interim Policy. Current schedule calls for MRIC

review in December 1997 and, assuming approval, distribution to the commands and bases during January 1998.

(Mr. Olen Sheperd, HQ USAF/ILMW, DSN 227-2389, sheperdo@af.pentagon.mil)



Student research is a key component of the Air Force Institute of Technology's Graduate School of Logistics and Acquisition Management programs. All students, working either alone or in teams of two, complete a master's thesis during their course of study. Many of the thesis research efforts are sponsored by agencies throughout the Department of Defense (DoD). Recently completed theses are listed below and focus on "real world" problems. A copy of each thesis is available through the Defense Technical Information Center (DTIC), Cameron Station, Alexandria VA 22304-6145, DSN 284-7633.

Leslie M. Norton Pride in Excellence Award (Outstanding quality) (four recipients)

Title: *Meeting US Defense Needs in Space: Effects of a Shrinking Defense Industrial Base on the Satellite Industry*

Author: Captain Ronald B. Cole (AFIT/GCM/LAS/97S-2)

Advisors: Major Caisson M. Vickery, PhD (AFIT/LAS) and Major Mike Hale (SAF/ST)

Sponsor: National Reconnaissance Office, Chantilly VA 20151-1715

US defense industrial base (DIB) deterioration and increased DoD interest in space exploitation highlights the US satellite industry as one DIB sector requiring analysis. Despite DIB problems, this industry must maintain the capability to produce advanced satellites for the DoD. According to experts, Commercial-Military Integration (CMI) will eliminate problems inherent with a separate DIB. This research focused on investigating satellite industry capability to meet DoD space requirements. Through literature review, case study analysis, and interviews, effects of a shrinking DIB on the satellite industry were determined. A model for DIB strength was developed and analyzed through literature review. A General Electric Aircraft Engines (GEAE) case study showed the potential for commercializing the DIB. Research focused on satellite industry executives whose perspectives illustrated industry capability to meet defense space needs. Results indicated continued DIB deterioration unless government and defense industry leaders intervene. GEAE sales performance demonstrated how commercializing the DIB can provide stability. Interviews confirmed the satellite industry's ability to meet defense needs; however, space architecture and launch vehicle issues must be addressed. Through flexible manufacturing, dual use, and smaller, smart satellites and satellite services, this industry can produce high quality, inexpensive satellites for defense and commercial markets faster, providing additional surge and mobilization capability.

Title: *Relationships Between CRDA Elements and Benefits to the Government in Technology Transfer*

Author: Captain Mark J. Davis (AFIT/GSM/LAS/97S-1)

Advisors: Major Richard M. Franza, PhD (AFIT/LAS) and Lieutenant Colonel Stephen A. Giuliano (AFIT/LAS)

Sponsor: AFMC/TTO, Wright-Patterson AFB OH 45433

Technology transfer has become an increasingly important mission of federal laboratories over the past decade, the results of which benefit the US government, private companies, and the nation's economy. Cooperative Research and Development Agreements (CRDAs) are the most used mechanism to perform technology transfer from our nation's federal laboratories to the private sector. The main objective of this research was to determine important CRDA elements that are associated with higher benefits to the government. Recommendations are provided for technology transfer managers to improve CRDAs by identifying the CRDA elements that are associated with higher or lower benefits to the government. Key findings include: (1) CRDAs, in general, provide many types of important benefits to the government; (2) CRDA elements that are associated with significantly higher government benefits include quantified manpower requirements, the commercial partner's ability to commercialize CRDA technology, CRDA technology market information, quantified copyright royalty rates, and quantified sales royalty rates; and (3) CRDA elements associated with significantly lower government benefits include detailed facility requirements and the CRDA technology's stage of development.

Title: *Applying Cross-Docking and Activity-Based Costing to Military Distribution Centers: A Proposed Framework*

Authors: Captain Dwight H. Hintz, Jr. and First Lieutenant Jonathan P. Elliott (AFIT/GTM/LAL/97S-3)

Advisors: Dr. William A. Cunningham (AFIT/LAL) and Lieutenant Colonel Terrance L. Pohlen, PhD (DSCC-BA)

Sponsor: WL/MTIM, Wright-Patterson AFB OH 45433

Current events and fiscal constraints have focused DoD planners' attention on reducing logistics costs and improving efficiency while at the same time, maintaining effective combat operations support. As a result, all of the military Services are examining private industry best practices that may help the DoD achieve these goals. Two commercially successful business practices, cross-docking and Activity-Based Costing (ABC), may help the DoD achieve its goals. Cross-docking is a commercially proven approach to material distribution through a distribution center that can reduce inventories, speed material flows, and cut related logistics activity costs. However, the DoD is faced with the challenge of costing current and potential logistics processes

with an antiquated costing structure. ABC may be able to answer the costing challenge and help military planners decide whether to invest in cross-docking technologies. This thesis provides a proposed framework for constructing a tool that can provide managers: (1) performance and cost measurements of current military distribution center operations, and (2) estimate expected performance and cost changes as a result of incorporating high technology cross-docking methodologies. The tool incorporates computer simulation modeling to measure the time performance, and a proposed ABC model to measure available versus used capacities and costs of existing and potential distribution processes and activities. The use of simulation for costing of activities and product costs is an unexplored area of ABC literature. Furthermore, ABC and simulation have not been used in conjunction to simulate and cost specific activities in a DoD distribution center. The implication for this research is to provide DoD managers a decision support tool for contemporary logistics decisions.

Title: *Development of the Base Support Plan Process Model For Evaluation of Proposed Process Improvement Initiatives*

Authors: Captain Daniel T. Kalosky and First Lieutenant Patrick G. Walker (AFIT/GLM/LAL/97S-4)

Advisors: Major Christopher J. Burke, PhD (AFIT/LAL) and Major Mark D. Caudle (AFIT/LAS)

Sponsor: AFRL/HESR, Wright-Patterson AFB OH 45433

The primary role of the USAF logistics planner is to plan for war. For the wing-level logistics planner, an important war-planning product they are responsible for is the base support plan (BSP). The BSP is the installation level plan to support unified and specified command wartime operations plans, as well as major command supporting plans. Two Air Force Research Laboratory sponsored initiatives exist to automate and enhance some of the BSP processes: the Survey Tool for Employment Planning (STEP) and the Beddown Capability and Assessment Tool (BCAT). This research explored the BSP process and improvement initiatives by: (1) flowcharting the current process, (2) establishing where in the current process STEP and BCAT play a role, (3) developing a spreadsheet model of the process using Microsoft Excel and the program evaluation and review technique (PERT) for quantifying any possible BSP scenario, and (4) computing the estimated time savings STEP and BCAT can provide the USAF in one of its areas of responsibility. The results of this research are threefold. First, a detailed BSP process map now exists filling a void experienced by logistics planners at all levels. Second, a model using Excel and PERT is available for users interested in improving their BSP process. This model can be adapted to any BSP scenario. And finally, the model showed the average time to complete a BSP with and without STEP and BCAT are significantly different.

National Contract Management Association Award (Significant contribution to contract management techniques)

Title: *Meeting US Defense Needs in Space: Effects of a Shrinking Defense Industrial Base on the Satellite Industry*

Author: Captain Ronald B. Cole (AFIT/GCM/LAS/97S-2)

Advisors: Major Caisson M. Vickery, PhD (AFIT/LAS) and Major Mike Hale (SAF/ST)

Sponsor: National Reconnaissance Office, Chantilly VA 20151-1715

(See Leslie M. Norton Pride in Excellence Award)

Project Management Institute Award (Clear understanding and command of project management techniques)

Title: *Relationships Between CRDA Elements and Benefits to the Government in Technology Transfer*

Author: Captain Mark J. Davis (AFIT/GSM/LAS/97S-1)

Advisors: Major Richard M. Franza, PhD (AFIT/LAS) and Lieutenant Colonel Stephen A. Giuliano (AFIT/LAS)

Sponsor: AFMC/TTO, Wright-Patterson AFB OH 45433

(See Leslie M. Norton Pride in Excellence Award)

Air Force Historical Foundation Award (Significant contribution to an understanding of the historical factors affecting an Air Force or DoD problem, event, or process)

Title: *International Armaments Cooperation in the Post-Cold War Era*

Author: First Lieutenant Paul L. Hartman (AFIT/GAL/LAL/97S-3)

Advisors: Dr. Craig M. Brandt (AFIT/LAL) and Lieutenant Colonel Karen W. Currie, PhD (AFIT/LA)

Sponsor: DUSD(I&CP), Washington DC 20301

During the height of the Cold War, the DoD had a focused acquisition effort to produce major weapons systems. Their high costs were justified by their sophisticated technology, which enabled the US military to gain and maintain air and ground combat superiority. However, with the collapse of the Soviet Union and an absence of a single galvanizing threat to global security, the US has been forced to drastically cut defense spending. Although there is no longer a central security concern for the US, there are new threats that require new defense objectives—and containing these threats is not expected to be cheap. Senior defense leaders agree the US policy of fielding technologically superior weapon systems will not change. What alternative, then, will effectively enable the US to meet reduced spending goals, yet maintain current national security levels? This thesis suggests that international armaments cooperation is one such alternative. The research was conducted using two methods, a literature review and personal interviews. These methods were selected to provide historical and current information on international armaments cooperation, as well as forecast the utility of cooperative programs in future weapons systems acquisitions. The literature review traced the evolution of international cooperative development from post-World War II up to the present. The personal interviews inquired about the status of current cooperative programs and the role of arms cooperation in the future. Both research methods revealed that international armaments cooperation, if implemented according to new models, is a viable alternative to former high-cost acquisition practices.

An Historical Perspective on the Future of Military Logistics

Lieutenant Colonel Karen S. Wilhelm, USAF

The battle is fought and decided by the quartermasters before the shooting begins.¹

—Field Marshall Erwin Rommel

No matter their nationality or specific service, military logisticians throughout history have understood the absolute truth represented in the above quote. Whether they were charged with supplying food for soldiers, fodder for horses, or the sinews of modern war—petroleum, oil, and lubricants (POL), they have understood that victory is impossible without them—even if, sometimes, it seemed their vital contributions were forgotten or ignored. None of the great military captains of history were ignorant of logistics. From Frederick the Great to Napoleon to Patton, they all understood the link between their operations and logistics. The great captains also have all understood that history had much to teach them about the nature of the military profession. Yet, military logisticians do not often spend time studying the history of military logistics.

This article is an attempt by one military logistician to derive relevant general lessons from history that might prove of some use in understanding how best to prepare for the future. There are at least three such general lessons. The first of these is the best case operationally is often the worst case logistically. The second is promises to eliminate friction and uncertainty have never come to fruition. And the third is technological change must be accompanied by organizational and intellectual change to take full advantage of new capabilities. While these lessons are not exclusive to logistics, when applied to the understanding and practice of military logistics, they provide a framework for understanding the past and planning for the future.

Such a framework is vital, now more than ever. Documents such as *Joint Vision 2010*² and the follow-on work supporting it are designed to set the course for the US military for the next 15-25 years. Logisticians not only must be proactive in helping set that course, they must use all resources available to ensure it is the right course. A thorough understanding of these three lessons will be of use in this regard.

The Lesson of the Best Case

The truth of the sentiment expressed by Field Marshall Rommel was no more apparent than on 2 September 1944 when General George S. Patton's 3rd Army ground to a halt from lack of fuel. The subsequent pause by Allied forces after their breathtaking race across France allowed the Germans to regroup and reconstitute their defenses and contributed to the extension of the war by another eight months. Given the logistical riches of the Allies, one is forced to ask why they allowed this to happen. The answer is their failure to plan for the "best case."

The historical record shows that September 1944 was not the only instance of logistical failure in spite of logistical riches.

Logistics planning for "best case" possibilities is just as important as planning for the worst case in supporting military operations. In fact, the best case operationally is often the "worst case" logistically, and the following historical examples support this assertion.

The first historical example is provided by the German invasion of France through Belgium in 1914. The German troops marched farther and faster than the peacetime planners had calculated. Since other logistics calculations were predicated on the estimated rate of advance, they were also in error. As a result, the railheads could not be kept within supporting distance of the advancing armies, and heavy transport companies were totally inadequate. The failure to plan for the operational best case—a quick breakthrough and advance—could have had a serious impact on the capabilities of the combat forces. In this particular case, it did not because the French halted the German advance before logistics difficulties could. Be that as it may, the evidence indicates the Germans would have had to halt due to logistics problems, and they got as far as they did only through "furious improvisation."³

The second example of failure to plan for the best case is from the North African campaigns of World War II. Both Rommel and the Allies succeeded in putting their operational best case into motion, but ultimately failed because these proved to be the logistical worst case. On at least two occasions, Rommel's offensives achieved massive breakthroughs against the British in the east. He was, however, unable to translate these tactical successes into lasting operational or strategic success because he had completely outstripped his logistics system. Given the distances involved, the primitive transportation infrastructure, the lack of coastal transport capabilities, and British air superiority, and the lack of effort in correcting these deficiencies, his actions were logistically unsupportable.⁴

Allied efforts in the west after the landings of Operation TORCH were similarly hindered. The failure to effectively plan for the best case was even more egregious in this instance, however, since they were operating from a position of abundance rather than scarcity. The key objective after the landings was to occupy Tunis before the Germans. The best case operationally was no resistance from French forces and a lightning advance to the east. In order to support this logistically, the Allies would have had to reconstitute and augment the existing rail system and bring enough trucks to fully exploit the limited road network. Yet, they did not allocate enough resources to accomplish the task and support the advance. The number of vehicles transported with each convoy was successively reduced with each iteration of the plan. The focus was on the mere accumulation of supplies—to the point that by the time the plan was executed, the port capacity was approximately two and a half times the combined rail and road capacity.⁵

The third example of the best case planning error, and perhaps the most inexcusable from the standpoint of not having learned from experience, is the Allied advance across France. On 25 July 1944, the Allies were 44 days behind schedule. On 31 August, Patton was 150 miles and five months ahead of schedule. The 6000 trucks of the "Red Ball Express" were using 300,000 gallons of gasoline daily to bring him the 350,000 gallons a day that he needed. By 2 September, he had to stop when the entire improvised system collapsed.⁶

Logistics planning for the breakout from the Normandy beachheads was based on the assumption of a slow, deliberate advance in the face of an orderly German withdrawal. The supply sequence entailed arrival at beach, port, or harbor, and then transport by rail and truck to supply dumps within tactical distance of the advancing forces. The worst case planning of the logisticians involved the possibility of higher consumption rates than projected. Consequently, the actions taken to preclude the worst case were focused on the accumulation of supplies. As noted above, the actual worst case logistically resulted from the best case operationally. The advance far outstripped the schedule, and transportation capability became the limiting factor. By the time Patton had to halt, POL and ammunition stocks were increasing on a daily basis at the beaches and ports, but could not be brought forward.⁷

The lesson of these three examples can be summarized as follows. World War I marked a turning point for military logistics. Prior to this time, a moving army was easier to supply than a stationary one because food (for men and animals) was the critical element, and the means to obtain it was through foraging. After 1914, the moving army was much more difficult to supply because the critical element was ammunition (and subsequently, POL), for which foraging is not a viable option.⁸ The logisticians learned this lesson almost too well. Their focus became the accumulation of supplies before the beginning of operations and their "worst case" became the point when consumption outstripped accumulation. These examples show, however, that accumulation is only half the equation; the other half is transportation. And in modern mobile warfare, the best case for the tactical forces, for example, the greatest rate of advance, is often the worst case for the logisticians supporting them because of limited transportation capability.

The Lesson of Friction and Uncertainty

The second historical lesson for logisticians involves the nature of friction and uncertainty. Throughout history, military planners have sought to reduce and even eliminate these two facts of life. The side that has made the greatest strides toward doing so, or at least made greater strides than its enemy, has also taken great strides towards winning. It has become increasingly tempting with our modern technologies to claim proximity to the "Holy Grail" of their actual elimination. *Joint Vision 2010* uses phrases such as "dominant battlespace awareness," the "uninterrupted flow of information," and "full dimensional protection."⁹ An even more insidious problem occurs when friction and uncertainty are assumed away without even a cursory reference. Logisticians must be aware of and avoid the pitfalls inherent in this approach.

In *On War*, Carl von Clausewitz first applied the concept of friction to the analysis of war. A series of quotes will serve to illustrate his meaning.

Friction . . . is the force that makes the apparently easy so difficult . . . friction . . . is everywhere in contact with chance, and brings about effects that cannot be measured. . . . The good general must know friction in order to overcome it whenever possible, and **in order not to expect a standard of achievement in his operations which this very friction makes impossible.**¹⁰ [emphasis added]

Friction, in other words, is a rather more elegant expression of Murphy's Law. Clausewitz was trying to tell us that military operations exist in the realm of Murphy's Law, and that good commanders adjust their plans accordingly, rather than trying to eliminate it.

Logisticians are subject to the effects of friction and uncertainty almost every day, and yet, often forget their effects when planning—or, conversely, try to anticipate and plan around every possible contingency. The earlier discussion of "the best case-worst case" dichotomy serves to illustrate this point as well. Another example occurred during British operations against the Argentines in the Falklands. The ship *Atlantic Conveyor* was sunk by the Argentine Air Force before she was able to unload her cargo of helicopters, airfield construction equipment, and tents. The British plan was predicated on concluding operations as quickly as possible—primarily because of the long lines of communication and the weather. The cargo sunk with *Atlantic Conveyor* constituted a large part of their capability to do so. "Her loss, while removing the means to speed up the operation, made an early termination even more imperative."¹¹ One is forced to ask why all such vital cargo was loaded on one ship; apparently no one anticipated the effects of such a loss.

The converse "sin" of trying to eliminate friction by anticipating and planning for all possible contingencies can lead to such rigidity that an unanticipated event or last-minute change is completely disastrous. The most obvious example of such a circumstance is the German mobilization for World War I. German logisticians had planned their two-front war in impeccable detail—right down to the number of trains over each bridge in a given time. And when the Kaiser asked Von Moltke to fight only to the east, against the Russians, Von Moltke answered, "it cannot be done . . . If Your Majesty insists . . . [the army] will not be an army ready for battle but a disorganized mob . . . with no arrangements for supply. Those arrangements took a whole year of intricate labor to complete."¹²

It is tempting to think that we would never do such things. It is tempting to think that it is a different age, that such rigidity is unnecessary now. It is tempting to think that Murphy's Law is "not as bad as it used to be" because we have such wonderful technology. It is tempting, but we would be wrong to draw such conclusions. Friction and uncertainty will remain with us because of three immutable factors.

First, human beings are still an integral part of the logistics system—and human beings make mistakes, and sometimes act irrationally. They get bored and enter data into their computers incorrectly. They work for four or five days with minimum sleep and then fail to secure a load properly—and it falls off the truck and is lost. They feel the pressure of on-going operations where mistakes can cost lives, and make even more mistakes. Our friend Clausewitz pointed out that the military machine "is composed of individuals, every one of whom retains his potential of friction."¹³

The second reason that friction and uncertainty will remain with us is that the military is a complex system, in the scientific use of the term. According to Charles Perrow, complex systems are those systems with multiple interactions among parts, procedures, and operators. These systems are subject to interactive failures because their designers and users cannot anticipate all the possible interactions and are, therefore, unable to predict all the possible outcomes of any given decision.¹⁴ Such complexity produces surprise. Unforeseen outcomes result when minor variations lead to some unpredictable total. Organizations typically react to these unpredictable results by adding more complexity, thereby exacerbating the problem rather than solving it.¹⁵ One need only examine the examples discussed earlier, or the surprise achieved by the Japanese at Pearl Harbor, in light of this definition to see how it holds true for military organizations.

The final reason military logisticians cannot escape friction and uncertainty is that the ultimate "consumer" of military logistics is an enemy who has a vested interest in ensuring the logistics system fails. Again, Clausewitz has captured the fundamental idea: "The whole of military activity must . . . relate directly or indirectly to the engagement. The end for which a soldier is recruited, clothed, armed, and trained, the whole object of his sleeping, eating, drinking, and marching is simply that he should fight at the right place and the right time."¹⁶ The whole object of the logistics system is the same, and the "leaner" we make the system, the scarcer the resources become, the more dependent we are on critical information nodes, the more lucrative a target we have created. The *Atlantic Conveyor* is an example of such a target.

The Lesson of Change and Innovation

The third historical lesson for logisticians is that organizational and intellectual change must accompany technological change in order to take full advantage of new capabilities. Innovations do not necessarily result from new technologies. New technologies may simply be used to do existing missions better. Innovations occur when new procedures are built around changes in the way organizations relate to each other and to the enemy.¹⁷

Again, the best case-worst case dichotomy discussed previously is applicable. For example, the problems experienced by Allied logisticians in supporting the breakout and pursuit across France were as much a failure to adapt intellectually and organizationally as anything else. The planners had already experienced the logistical problems of North Africa, but failed to adapt.

The foundation of that failure to adapt was the failure to recognize that a change in operational concept warranted a change in logistical support concept. The mobile tank warfare pioneered by the Germans highlighted the fact that not only had tactical mobility been restored to the battlefield, it had increased by an order of magnitude. These operations focused on the application of combat power through combined arms and the shock inherent in high-tempo operations. The necessary logistic change was in supporting the high tempo of operations—not just movement, but speed of movement. This was the primary failure of the logisticians—the failure to recognize the need to support the tempo change—an intellectual and organizational change.

The Germans also failed in this regard. Although not apparent in the early campaigns, it was highlighted once they attacked into

the wide-open spaces of the Soviet Union. Although the logistics failure was not the sole or perhaps even the primary cause of the German defeat on the steppes of Russia, it was a major contributor.

The Germans had only partially motorized their combat forces and only a small proportion of their logistics support was moved by truck. The remainder was tied to the use of railroads and animal transport. This weakness was masked in the campaigns in Poland and France by the relatively short distances and the rapid collapse of enemy forces. The vast distances encountered on the Russian Front, coupled with the resilience of the Soviet forces, served to expose this problem and caused the German soldiers to suffer horribly.¹⁸

The noted military historian, Williamson Murray explains that:

Relations among technological innovations, fundamentals of military operations, and changes in concepts, doctrine, and organization that drive innovation are essentially nonlinear. Changes in inputs . . . may not yield proportionate changes in outputs or combat dynamics.¹⁹

During periods of transition, in particular, there are significant intellectual, organizational, and technological changes. The key change, however, must be intellectual change, for without intellectual change, technological change is essentially meaningless, and organizational change is impossible. Logisticians who grasp at technological change without making the necessary organizational and, more importantly, intellectual changes to fully understand and make best use of new technologies, are doomed to failure. Intellectual change is the requirement to make all others meaningful.

Implications for the Future

In order to examine the implications these lessons hold for the future of military logistics, one must first examine current views regarding the future of military operations. The US military has entered a period of rapid change. Orders of magnitude improvements in technology have resulted in recent attempts to devise long-range plans to incorporate those improvements into new weapon systems and operational concepts. *Joint Vision 2010* and the documents supporting its implementation provide the guidance for thinking about these new concepts.

In the logistics arena, *Joint Vision 2010* explains the concept of Focused Logistics—defined as "the fusion of information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets even while en route, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical levels of operations."²⁰ The vision of Focused Logistics includes enhanced mobility and versatility of combat forces anywhere in the world through the elimination of vertical logistics organizations and the use of tailored combat service support packages and pinpoint delivery systems.²¹

Joint Vision 2010 heralds the creation of two other key concepts—dominant maneuver and full dimensional protection, the latter being simply the complete protection of forces and lines of communication "from fort to foxhole." Dominant maneuver is envisioned as combat forces operating from dispersed locations in sustained all-weather, day or night operations at a decisive speed and tempo. It is "a prescription for more agile, faster moving joint operations."²²

The underpinning for all these concepts is the idea of information superiority—"the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same."²³ The *Concept for Future Joint Operations* explains further that the view of operations in 2010 is predicated on the reduction of friction through greater battlespace awareness. This greater battlespace awareness is conceived as a comprehensive and complete view in space and time; using assured, secure, and responsive information; and resulting in the capability to predict enemy intentions and actions.²⁴

Given the nature of this vision of the future, the three historical lessons that are the subject of this analysis are clearly applicable. In general terms, these documents discuss the need for organizational change and they constitute at least an attempt at intellectual change. It is too early in the process of change to expect specific suggestions for modifications to existing military organizations. The intellectual change exhibited is part of the current debate regarding an on going "Revolution in Military Affairs." A discussion of whether this revolution actually exists or not is beyond the scope of this article, but the authors of the joint vision documents clearly believe it does.

With regard to the best case-worst case lesson, it would seem the logisticians of the future would still be susceptible to the effects of this dichotomy. The concept of dominant maneuver is focused on speed, tempo, and agility of operations—from dispersed locations. The logisticians' tasks would seemingly be made even more difficult than today. Those who compose this vision of the future would answer that the concept of focused logistics would enhance the mobility and versatility of the logistics forces to the point that they matched that of the combat forces. This is entirely possible, but given that history shows that combat forces are typically ahead of support forces in gaining improved capabilities, it is also entirely possible that logisticians will again find themselves in the position of their worst case being the best case operationally.

It is in the arena of friction and uncertainty that the US military's vision of the future would seem to be most lacking. Combat forces are visualized as smaller and more capable, supported by smaller and more capable logistics forces. The system of forces and support requirements is highly complex and interdependent with little or no slack or excess capability. These forces are to sustain operations around the clock, and success is dependent upon a continuous supply of vast quantities of absolutely accurate information. Although there are occasional disclaimers in the documents to the effect that fog and friction will remain, the concept belies these words—there is no discussion of how the system will cope with or overcome friction and uncertainty.

The only conclusion to be drawn is that the visionaries attempting to set the course for the future of the US military have failed to learn this lesson from the past. They are designing a tightly coupled system of systems. Within that system will exist interdependencies and implicit assumptions that will defy ready understanding and, therefore, result in unexpected outcomes. They are designing a system that is still subject to the vagaries

and weaknesses inherent in human beings, but without taking those vagaries and weaknesses into account. They are designing a system which makes the logistics portion such a lucrative target that a potential enemy can have a greater impact by striking against logistics capability than by striking at combat capability. The failure to appreciate the effects of friction and uncertainty has had grave consequences in the past, and we are creating the potential for the same grave consequences.

These three lessons hold meaning for the future of military logistics. History has shown logisticians can fail if they do not understand the best case-worst case dichotomy, if they do not appreciate the need for intellectual and organizational change, and if they do not take into account the effects of friction and uncertainty. While no one should expect history to repeat itself, logisticians can benefit from the study of history with a view toward understanding the errors of the past and the applicable lessons for the future.

Notes

1. *The Rommel Papers* as quoted in Martin van Creveld, *Supplying War: Logistics from Wallenstein to Patton*, Cambridge: Cambridge University Press, 1977, p. 200.
2. Chairman, Joint Chiefs of Staff, *Joint Vision 2010*, Washington DC: Pentagon, 1996. Hereafter JV2010.
3. Ibid, pp. 138-140.
4. Ibid, pp. 199-210.
5. Thompson, Julian, *The Lifeblood of War: Logistics in Armed Conflict*, Oxford: Brassey's, 1991, pp. 56, 61-67.
6. Van Creveld, p. 213.
7. Ibid, pp. 212-213, 220-221.
8. Thompson, p. 50.
9. JV2010, pp. 13, 16, 22.
10. Von Clausewitz, Karl, *On War*, trans. and ed. Michael Howard and Peter Paret, Princeton NJ: Princeton University Press, 1976, pp. 120-121.
11. Thompson, pp. 278-279.
12. Tuchman, Barbara W., *The Guns of August*, New York: MacMillan Publishing Company, 1962, pp. 74-75, 79.
13. Clausewitz, p. 119.
14. Perrow, Charles, *Normal Accidents: Living with High-Risk Technologies*, New York: Basic Books, 1984, pp. 4, 11-12.
15. Demchak, Chris C., *Military Organizations, Complex Machines: Modernization in the U.S. Armed Services*, Ithaca NY: Cornell University Press, 1991, pp. 3-5.
16. Clausewitz, p. 95.
17. Rosen, Stephen P., *Winning the Next War: Innovation and the Modern Military*, Ithaca NY: Cornell University Press, 1991, p. 134. See also Williamson Murray and Allan R. Millett, *Military Innovation in the Interwar Period*, New York: Cambridge University Press, 1996, for a book-length treatment of this subject.
18. Cooper, Matthew, *The German Army 1933-1945*, Lanham MD: Scarborough House, 1978, pp. 311-312, 331.
19. Murray, Williamson, "Innovation: Past and Future," *Joint Forces Quarterly*, (Summer 1996), p. 52.
20. JV2010, p. 24.
21. Ibid.
22. Ibid, pp. 20-21.
23. Ibid, p. 16.
24. *Concept for Future Joint Operations* (Preliminary Draft Version 4.0), Ft. Monroe VA: Joint Warfighting Center, 21 Mar 97.

Lieutenant Colonel Wilhelm is presently the Commander of the 715th Air Mobility Squadron, Travis AFB, California. **JE**

Operation URGENT FURY: Grenada

*Captain Thomas J. Snyder, USAF
Captain Stella T. Smith, USAF*

Editor's Note: The following article is Chapter 1 of The Logistics of Waging War, Volume 2, US Military Logistics, 1982-1993, The End of "Brute Force" Logistics, which was recently published by the Air Force Logistics Management Agency. This monograph chronicles logistics efforts and operations from 1982-1993 and examines the final chapters of what has been aptly called the era of "brute force" logistics. Volume 2 is available on the World Wide Web (<http://www.il.hq.af.mil/aflma/lgi/lww2.html>) and will soon be available through the Air Force PDO system.

In 1983, the United States led a military operation in Grenada to restore a viable Grenadian government. This operation, URGENT FURY, came about as a response to a request by the Organization of Eastern Caribbean States (OECS). Cuban military units had established fortifications, arms caches, and military communications facilities on Grenada (1:3). The OECS became concerned that the political institutions in place represented a threat to the security of the region.

Objectives

Two key objectives of URGENT FURY were the evacuation of US medical students along with any others who wanted to leave and the evacuation of Governor General Sir Paul Scoon.

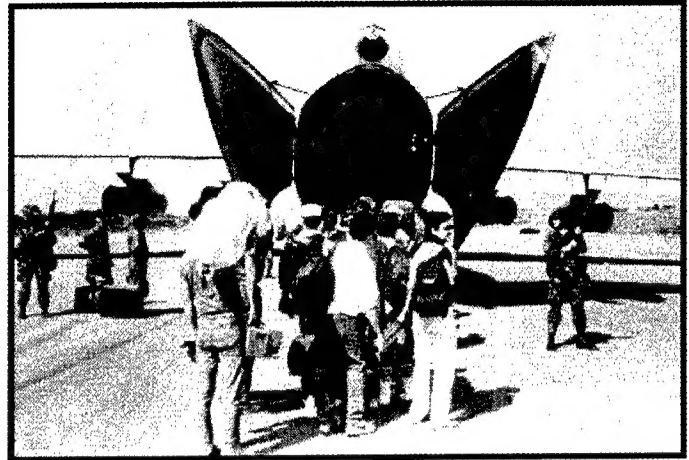
Logistics Considerations

To meet the objectives for this operation, many different areas of logistics had to be identified and planned. One requirement was to decide how to secure the airport and identify what would be needed to do this. Questions to be answered included: how many men would be needed, and what type of equipment, ammunition, and support would they need?

The other major requirement was to determine how to locate, protect, and extract the students efficiently. Considerations included the type of airlift, food for the students, and any prisoners of war that might be taken. Answers to the above issues would determine what assets and supplies would be brought to the island. Another logistics challenge was coordinating the roles of the Services involved. The Air Force, Navy, Army, and Marines all had missions to perform in this operation. Each service had its own logistics problems to handle. The joint nature of this operation required extensive logistics coordination.

During the morning of the first day of the conflict, Army Rangers secured an airfield at Point Salines. This was the only runway that could accommodate a C-141.

The runway was still under construction at that time. A large number of troops and corresponding supplies needed to be brought through this one airfield and only one large aircraft could be handled at a time. This required an extremely fast turnaround



American medical students board a C-141 for evacuation from Grenada. (Official US Navy photo)

time to unload and get the plane airborne again. During the early part of the operation, ground support would turn around the aircraft within 30 minutes (2:4). The first troops on the scene brought the equipment needed to off-load the aircraft that would be following. These people needed to determine where to store the off-loaded cargo so it could be accessed when needed without impeding the use of the landing strip.

Constraints

The operation experienced many logistics constraints. Three examples were limited airfield capacity, fuel resources, and potable water.

Getting the necessary supplies to the theater was difficult (3:59). Each service requested strategic airlift directly from the Military Airlift Command. No single command coordinated and prioritized the airflow based on operational need. Due to limited runway capability, landings were made on a first-come, first-served basis, with the amount of fuel on board dictating an aircraft's status in the queue. Some aircraft carrying essential logistics supplies were diverted to other airfields for refueling, which meant there was a continuous competition for access to the airfield. The lack of a prioritization system meant the same shipment could be bumped multiple times, and there was no way to accurately predict when critical supplies would arrive.

This confusion could have been avoided if the existing logistics doctrine had been followed. The existing doctrine would have had all airlift requirements forwarded to the Atlantic Command J-4. Thus, all the requests could have been reviewed and validated prior to going on to the Military Airlift Command. A priority order could have been developed which rescheduled less critical flights (3:59).



US servicemen gather their gear after landing at Port Salines in Granada. (Official US Air Force photo)

The airfuel reserves located at Seawall International Airport in Barbados were rapidly depleted by airlift refueling. This forced a change in airlift operations. Maximum allowable cargo payload was reduced from 50,000 to 35,000 pounds to enable aircraft to make the round trip from stateside locations without having to refuel (3:59).

The island of Grenada did not have a large supply of potable water. Intelligence received on this logistics issue proved inaccurate. It was initially thought that water would be readily available. However, the fresh water supply was low and to complicate the matter, the water system at St. George was rendered inoperable early in the conflict. Water was resupplied by air until desalinization units arrived and were put into operation.

Logistics Successes

The Deployable Mobility Execution System (DMES) was used to support the operation. This portable software application was designed to allow a load planner to process materiel needed to be airlifted to the theater based on its weights and dimensions. The system was intended to save deployment of aircraft by more effectively loading the C-141s being used (4:10). DMES allowed planners to build the most efficient load plans based on lists of equipment and personnel required. In one instance the planning was accomplished in 20 minutes and saved the use of one aircraft by loading all of the required materiel on only four planes instead of the anticipated five aircraft. DMES was used to plan for the airlift of nearly 7,200 short tons of cargo and over 7,500 troops to Grenada (5:2). The use of this software also allowed planners to quickly change loading plans to accommodate the dynamic priority lists that came from field commanders.

A Forward Area Support Team (FAST) was deployed to support the forces. Since maintenance would be required from the beginning of the operation, the FAST was to coordinate the

early maintenance problems and help to solve them quickly. They established an operation located at Salines airfield. Their duties were to set up a facility to collect requests for spare parts from all sources until the Division Material Management Center (DMMC) would arrive. The FAST would collect the requests and forward them to Fort Bragg, North Carolina, via the Tactical Satellite (TACSAT) or facsimile machine. Once the main body of DMMC personnel set up, all requests would go through them so they could use the information available through the TACSAT and Rear DMMC to find the most expeditious method of getting the parts (2:6).

Lessons Learned

The issue of joint logistics was not given proper consideration during the planning stage of Operation URGENT FURY. Each service addressed logistics planning autonomously, which made transferring supplies across service boundaries a formidable task. There was no single ground commander coordinating logistics efforts which resulted in a duplication of effort and competition for scarce resources between the individual Services.

Even though Operation URGENT FURY was an overall success, the operation revealed some logistics limitations. This influenced the Department of Defense Reorganization Act of 1986, which placed new emphasis on joint assignments and gave combatant commanders authority in all aspects of logistics. New joint exercise programs were also implemented to improve joint logistics (3:62).

Operation URGENT FURY highlighted the advantages of conducting an operation with bases already located in the theater. The use of a large secure runway was a tremendous benefit. In addition, the large number of troops already stationed in Grenada and intelligence about the opposition facilitated easier implementation of logistics plans. These factors need to be considered when applying the lessons learned from this operation.

References

1. "Why Grenada," *The Ordnance Magazine*, Vol. 2, No. 1 (Winter 84), p. 3.
2. Sever, Kenneth C., Lt Col, "Units and Missions, 782d Maintenance Battalion in Grenada," *The Ordnance Magazine*, Vol. 2, No. 1 (Winter 84), pp. 4-6.
3. Harper, Gilbert S, "Logistics in Grenada: Supporting No-Plan Wars," *Parameters*, Jun 90, pp. 50-63.
4. Walker, Carol A., Capt, "DMES: A Giant Step Toward Increased Airlift Capability," *Airlift* (Spring 84), pp. 10-11.
5. Walker, Carol A., Capt, "AFLMC Developed System," *The Dispatch*, 12 Jan 84, p. 2.

Captain Snyder is presently a Logistics Career Broadening Officer at the San Antonio Air Logistics Center, San Antonio, Texas. Captain Smith is presently a Squadron Maintenance Officer at the 35th Fighter Squadron, Kunsan AB, Republic of Korea.

JE

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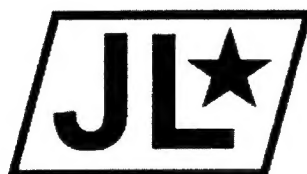
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